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THE TRUCKEE-CARSON RECLAMATION PROJECT.*

By Enos Brown.

The very remarkable work which is being prosecuted by the government in the State of Nevada for the reclamation of a large area of the arid territory in that region is approaching demonstration. In the summer of 1905, 30,000 acres of parched lands received copious supplies of water and were transformed from a desert on which nothing has ever grown except sage brush or greasewood into a land covered with luxuriant verdure of alfalfa, corn, fruits, and vegetables, and affording homes for thousands of thrifty and industrious citizens. To effect such a marvelous change in the superficial aspect of the land has required large financial outlay and engineering capacity of the highest order. There is not an engineering problem in irrigation that has not been put to a severe test in the comprehensive methods pursued in constructing the plant of the Truckee-Carson reclamation project. Nature has assisted in providing a magnificent system of water supply and adequate material for the work, but mountains had to be tunneled, wide and deep cuts excavated, and great valleys filled with earth, before the gigantic canals, which are to provide floods of water to the thirsty land, could be located at sufficient elevations and required grade.

The lands to be irrigated by that portion of the system now under consideration are situated in Washoe, Stoney, and Churchill counties, and Carson Sink valleys. A large portion of these lands are open

* Specially prepared for the Scientific American Supplement.

ENTRANCE TO THE TUNNEL.

A ROCK CUT ON THE CANAL.

A HIGH SIDE CUTTING.

BLASTING ON THE CANAL.

CONTRACTOR'S CAMP IN THE DISTANCE. DITCH LINE AT THE FOOT OF THE MOUNTAIN.

BREAKING THE FIRST GROUND FOR THE UNITED STATES IRRIGATION CANAL. NEAR WADSWORTH, NEV.

Photos by E. L. Linton.

THE TRUCKEE-CARSON RECLAMATION PROJECT.

to entry under the Homestead Act. The sources of water supply for the system are Tahoe and numerous other lakes of the western slopes of the Sierra Nevadas and the Carson River.

Lake Tahoe has an area of 195 square miles at an elevation of 6,247 feet. The annual run-off is 900,000 acre feet. At the outlet a concrete dam, which raises the water level 6 feet above ordinary low, has been erected and adds to the present storage capacity of the lake 750,000 acre feet, available as required.

Donner Lake has also been raised and the ordinary storage of water considerably increased. Carson River has its source in the high sierras and is fed by the melting of enormous banks of snow as well as by streams flowing from numerous small lakes. The river is 180 miles in length and empties into the twin Carson lakes, where the waters are lost in the sands. Its flow varies according to the season. In early summer the run-off sometimes reaches 7,500 second cubic feet, but is reduced to 300 second cubic feet in the autumn months. In its course the Carson River falls 5,000 feet. From Lake Tahoe to Pyramid Lake the Truckee River descends, in the 125 miles of its course, 2,399 feet. While the volume of this stream varies it is never less than 750 second cubic feet. Both rivers being mountainous and flowing through deep and narrow cañons, in many places they afford fine opportunities for storage reservoirs, of which full advantage has been taken. Tahoe furnishes the most constant and abundant water supply for the system, as does Donner Lake, though less in quantity; but there will be constructed other reservoirs of which five, having a storage capacity of 290,000 acre feet, will be located on the upper Truckee, three on the upper Carson River, holding altogether 250,000 acre feet, and one on the Lower Carson holding 290,000 acre feet. The water stored will supplement the normal flow of the two rivers. Dams and water gates of reservoirs will, in most instances, be concrete.

The amount of earth to be excavated on the portion of the system just completed is 2,500,000 cubic yards. In addition, 450,000 cubic yards of rock have been taken out. On the main canal there are three tunnels of respective lengths of 508, 900, and 1,575 feet. These are lined with concrete and are of identical inside dimensions, being 12 feet in width, 12 feet to the spring of the arch, and 86 feet extreme height above the floor. All of the sides of the rock cuts are also concreted.

At an altitude of 4,225 feet and a point 25 miles east of Reno the great Truckee dam has been erected. The river carries 1,400 second cubic feet, which is diverted to the main canal beginning at the dam, and runs east and southeast for a distance of 31 miles. Six miles below the dam a branch intersects the main canal and diverts 200 inches of water on to 25,000 acres of land in the Pyramid Lake Indian reservation. The main canal continues its course to a reservoir on the lower Carson River, situated about 10 miles above the town of Leetville. For the first six miles of its length the canal will carry 1,400 cubic inches and for the balance of the distance 1,200 cubic inches. The branch to Pyramid Lake crosses the Truckee through a siphon. The main canal has dimensions of 13 feet in depth, width in cuts 9 feet, and ordinary width at bottom of 23 feet.

Eight years will elapse before the system will be complete and the irrigation of the 375,000 acres as contemplated be accomplished. The works will then, it is estimated, have cost the nation $9,000,000, which will be reimbursed by the sales of water rights and land.

Even when complete and all the land under the system is disposed of, the control and management will not be relinquished by the federal government, which has undertaken to deliver water upon every section of land within the territory covered by the main canals. The subsequent cost of maintaining and operating the system will be borne by the homesteaders, who will form water users' associations and enact such proper rules and regulations for the use of water as may appear desirable, but no regulation is of the slightest effect without the sanction of the United States Secretary of the Interior. The cost of the land to the homesteader is placed at $26 an acre, payable in ten installments; the first payment is in December subsequent to the first crop secured. The government asks no interest. The comprehensive nature of the undertaking views the possibility of the prevalence of alkali on the lands and proposes to eliminate this objectionable feature by a resort to subdrainage. In such instances the government will construct ditches for carrying away affected waters. In a few years lands can be cleared of alkali by subdrainage and made equal to the best in the district.

The results of the early completion of the great irrigating project is very tangible and indicates a rapid development of the district. On every hand the homes of the new settlers may be seen, hundreds of them, occupying the section which has been selected. Hazen, a town in Churchill County, not many months ago a desolation, has now substantial buildings, well-laid-out streets, and a busy population. Little hamlets mark new railroad stations every few miles. There is an aspect of permanence in all these new settlements, which indicates an abiding faith in the future.

The lands under the main canal are described as "valley" consisting of sandy loam and ash, but in the lower Carson Valley are heavier, containing an admixture of clay. Alfalfa grows luxuriantly upon the lands, which are also suitable for sugar beets, potatoes, grain, and fruit. Clearing involves but little effort, the sage brush plant being easily exterminated.

The climate of the region traversed by the irrigating system is temperate. One hundred deg. in the shade is the extreme summer range and 6 deg. below zero is the very extreme of winter's cold. Frosts appear about October 1 and last until the 1st of May. There is but little humidity in the atmosphere and a yearly rainfall of 6 inches is rarely recorded; 4 inches is about the average for twelve months. Snowfalls of 3 inches seldom occur, and it never lies on the ground longer than twenty-four hours.

The future benefits to the great State of Nevada from the installation of the Truckee-Carson reclamation project are incalculable. The State has an arid surface of 36.15 per cent and an agricultural area of but 12 per cent. The addition of 375,000 to the productive acreage will increase the resources of the community millions of dollars yearly, and attract a particularly desirable class of settlers. Mr. L. H. Taylor, the United States government engineer in charge of the works from the beginning, asserts that the population of Nevada will be doubled even before the irrigation project is completed. He estimates a population of 30,000 will find a comfortable and adequate support on the lands without reference to the large number which will occupy the towns and hamlets springing up as a consequence of the cultivation of the great tract.

The irrigated region occupies the basin of a great lake, which geologists all agree submerged this section of western Nevada. Lake "Lahonta" covered 8,422 square miles and was 500 feet deep. The soil of the valleys was deposited during the existence of the lake. Pyramid Lake, 386 feet deep, is the greatest depression in the basin.

The topographical conditions of Nevada are unlike those existing elsewhere in the United States. The whole State comprises a great independent geological basin, complete in itself. The river system exhausts itself in the central depressions or sinks, and contributes nothing either to the volume of the Colorado River on the southeast or the affluents of the Columbia River on the north. The Truckee River is the "Jordan" of the West; rising in the pure, snow-fed Tahoe and descending in splendid volume and rapid current until it is received into the bitter waters of Pyramid and Winemucca lakes. The Carson River finally loses itself in the shallow basins of the two lakes which receive its waters. The absorption of the waters of the two streams by the Truckee-Carson reclamation district will inevitably work great changes in the map of Nevada. Upper and Lower Carson lakes will entirely disappear, while Pyramid and Winemucca lakes, now sustained by the waters of the Truckee, are bound to suffer great diminution in superficial area.

The lands to which the water of the two rivers will flow, which now present to the eye an aspect of Sahara-like aridity, will, as soon as moisture is applied, be transformed into gardens and become the scene of industrious thrift and a permanent source of wealth.

RAPID TRANSIT IN GREAT CITIES.*

By WILLIAM BARCLAY PARSONS.

ONE of the outcomes of modern civilization has been to collect populations into large centers, and with such segregation there has arisen a series of problems of which our forefathers took no heed at all or at most but little thought. A large city entails the supply of its people with light, heat, power, food, water, drainage, housing, pavements, and means of intercommunication. All of these problems except the last increase in difficulty and importance, substantially in direct ratio to the size of population. With transportation, however, the increase is as the square or even as the cube. Double the size of a city and you have not only twice as many people to carry, but you must carry them twice as far; and as the minute and not the yard is usually the proper unit of distance, doubling the distance means a doubling of speed. In New York, with its population of 3,750,000, there are being carried now on the surface, elevated, and subway systems paying passengers, exclusive of so-called transfers, 1,200,000,000 per annum, a number very much greater than the number of passengers on all the steam railroads of both the American continents from the Atlantic to the Pacific and from that most northern of all railroads, the Wild Goose Railway, near Nome, Alaska, within the Arctic Circle, to the most southern one in South America, the State Trunk Line, of Chili. London with its population of over 6,000,000, but with inferior interurban railway facilities, carries about the same number as New York; while Paris, Berlin, Hamburg, Boston, Chicago, and St. Louis are fast following in the leaders' tracks. Such figures need no further comment or explanation to indicate the dimensions of the problems of transit in great cities and the difficulty of properly meeting the continual demand for increase in facilities as cities grow.

The elevated railroad is essentially an American design, having been suggested first by Col. Stevens, of Hoboken, N. J., as early as 1830, only five years after the first steam passenger line was opened in England, and two years after a similar event occurred in America. It was not, however, for forty years that the suggestion was given practical application, and then to avoid in New York the difficulties experienced in London of working an underground line by steam locomotives. This form of construction was extended in New York, or what is now the boroughs of Manhattan and the Bronx of that city, during the following ten years, resulting in the present elevated system, with a length of thirty-eight miles of route.

We will now take up the other form of rapid transit railroad, the one beneath the surface. The first line of this character to be constructed was in London in 1865, but there the results of operating by steam locomotives were so disagreeable that no other similar move was made until another kind of motive power was possible. The next contemplated power was the cable, and the line built to receive it was the City & South London, the first of the so-called "tubes." But before it was completed in 1894, the practical feasibility of electricity as power on a large scale for transportation purposes had been amply demonstrated, so that an electrical and not a cable plant was installed. The attending success showed that it had become possible to use, with comfort and cleanliness, the great subsurface for transit purposes, a space hitherto considered of value only as a place wherein to bury sewers, water and gas mains in haphazard and disordered confusion. It is especially this use of the ground beneath our streets to which I desire particularly to direct attention.

The construction of the City & South London, with its electric installation, established a new order of things in two ways. First, it showed the feasibility of the new form of power application. Second, it showed the feasibility of tube construction. From this success a rapid development of underground construction began, and railroads of this character have since been built in Buda-Pesth, Paris, Berlin, and Glasgow, in Europe, and in Boston and New York, with one now building in Philadelphia. Constructively speaking, these railroads are of two quite different types, the very deep, and the very shallow. The former is represented by the tubular construction. Although this form of construction was first put to a practical completion in England, it is really of American origin, a short sample line having been constructed some forty years ago in New York by Mr. A. E. Beach, which sample still exists. In England it was developed by the late Mr. Greathead, in the City South London, and afterward by other engineers on three other lines, with two more now building.

In the matter of operation, substantially the same general principles apply to all rapid transit railroads, where the problem is how to move the greatest number of people over a given distance with the minimum of expense. Unless the mono-rail system possesses sufficient advantages to overcome their disadvantages and compel their adoption, nothing better has yet appeared than the ordinary railroad track of standard gage. This track should be of the heaviest type regardless of the light rolling stock, especially if high speed is to be attempted. Curves should be carefully spiraled, and superelevation given, not according to a fixed rule, but varying with each curve and adapted to the speed that trains will make at that particular point. With cars you will find a field wide open for fertility in design, and where there is a contest between advocates of end doors versus side doors. Except for the all-metal cars recently introduced in the New York subway to eliminate fire risk, there is not much of striking novelty advanced, and nothing that has any great bearing on economy of operation except the facility to unload and load passengers. Every second's delay at a station repeated by every train, say, four times per mile, and at train intervals of one minute, means an increase in the number of trains required to maintain a given service. In spite of many manifest advantages of side doors, the tendency of practice is toward the type of American car with end doors, such cars having been adopted on the several lines in London and on the recently-constructed combined subway and elevated in Berlin.

In the matter of motive power, the greatest advance has been made, and there probably remains the greatest possibility for future improvement. The steam locomotive, quite apart from the objectionable features of smoke, has already been permanently relegated to the scrap heap. For the moment, electricity is the only form of power that satisfies the requirements of the problem, and it will so continue until disturbed by some other. In order to maintain speed with frequent stops, the motors must have a high power of acceleration. In this respect the steam locomotive is sadly deficient. The best rate that the engines on the New York elevated could reach on loaded trains was 0.6 mile per hour per second, while the electric motors can give in actual practice 1.5 miles per hour per second. That is, in the first case twenty seconds were required to develop a speed of twelve miles, while only eight suffice in the latter case. Furthermore, the electric motors can be distributed throughout the train and so avoid heavy concentration. On an express train of eight cars in the New York subway there are five motor cars, with two axles each, equipped with 200-horse-power motors, so that the total power per train is 2,000 horse-power. This is the nominal rating, but the actual power, during a possible period of overload when accelerating, is at least 25 per cent greater. To equal this in steam locomotive practice would call for two locomotives of the heaviest passenger type. These motors thus distributed through the train are, of course, under simultaneous control by the motorman at the head of the train, or in case of emergency at any other point.

Power for these motors is produced at large central plants. The largest of such plants as yet constructed is that of the New York subway, where the main units have an output capacity of 10,000 horse-power, and where the total capacity of the whole plant, including subsidiary engines, is 135,000 horse-power. The cur-

* Abstracted from an address delivered at Purdue University.

rent as produced is of the alternating variety, and is generated at a pressure of 11,000 volts. As such it is carried to nine substations, averaging about two and one-half miles apart, where it is transformed to direct current and reduced in voltage to about 600 and thus fed to the line. The total weight of copper in the transmission cables on twenty-one miles of road in operation is over 6,500 tons, which would have been much increased if direct current alone had been used, and could have been reduced if alternating current could have been used throughout. The advance in design of the structural parts of elevated railroads or subways with reinforced concrete walls has substantially exhausted any great possibilities in economy of design. This, however, is not true in respect to power and its application. The cost of power per car-mile by steam operation on the New York elevated was 12.18 cents; by electricity, under methods employed to-day, it is 9.47 cents, a reduction of nearly 20 per cent, while at the same time the average speed through quicker acceleration has been raised from thirteen to fifteen miles per hour. It is possible that, by means of higher steam pressure, turbines in place of reciprocating engines, higher voltage for transmission, the use of alternating-current motors working at 3,000 volts, this cost can be still further reduced without imagining any radical departure from existing standards in practice.

In regard to operation, all but one of the rapid transit systems so far built are an extension of the principles of the surface service, that is, cars in units or in trains stopping at all stations. In New York, partially on the elevated lines, but more particularly in the new subway, the principle has been established in differentiating between the short and long-distance traveler, and in giving to the latter a special train service on separate tracks, stopping at stations about one and one-half miles apart instead of one-quarter mile. This marks to date the maximum development in rapid transit facilities, a development, however, that will probably soon be repeated elsewhere, and will eventually be exceeded in New York by an express service with even higher speed, that is, with fewer stops.

Let us now turn from the engineering consideration of the question and briefly take up the legal aspect. The first established lines of transit were the omnibuses, which differed so little from other vehicles that their use of the public highway without special charge or tax was considered an obviously proper use. When the omnibuses gave way to the horse car, it was held that such use was still proper, as the horse car was but an omnibus running on fixed lines, and the right to use public streets without payment was granted by the public authorities to street railway corporations. To-day, in practically every city in the United States, we find electric cars, the successors in turn of the horse cars and of their privileges, using public streets without franchise payment or at most with small ones. Such a result was not foreseen when omnibuses were first started. Now our economists are agitating a reversal of policy and demanding either that a proper payment shall be made for the right of way or that the title shall remain in the municipality, and that the right to run shall not be under a fixed grant, but under a lease.

The modern rapid transit railroad is an exceedingly costly structure. The tubular railroads for two tracks, including stations and equipment, are costing in London about £800,000, say $4,000,000 per mile. Portions of the New York subway, with four tracks but exclusive of equipment, cost $5,000,000 per mile, and the total cost of the structure for twenty-four miles, of which six miles are elevated and therefore comparatively much less expensive than the subway, cost $2,000,000 per mile, and the equipment will add $750,000 per mile in addition. A large modern urban railroad represents, therefore, a great aggregation of capital and the forming of a corporation with necessarily great power, both financial, social and political. In this respect some people see such danger that they are demanding that all such railroads should belong to the municipality in which they are located and be operated by it. In England, where this movement has progressed further than here, many of the surface railways have been bought by the public authorities. As to the success of the movement there are widely different opinions. The experiment has not reached a definite conclusion. While awaiting the outcome no municipality has as yet undertaken to own and operate a rapid transit railway, although such ownership, without operation, has been retained in three cases.

The existing lines maintain their corporate existence in two ways, either by proprietary right, or by lease from the municipality. As examples of the former, are the London railways and the elevated roads in New York, where special privileges have been conferred by law on the corporations, and they own, in their own right, the lines they have built. As examples of the latter, are the railways in Paris, Boston, and New York. In each of these cases the subways were built by the city itself, out of public funds, and then leased to a private company to be operated by it. In Paris the railroads are first built by the city at its own cost and by its selected contractors, and then turned over, as each piece is completed, to the same lessor company to be operated by it, the company paying to the city of Paris one-third of the gross receipts as rental. If this sum exceeds the interest on the cost, the city of Paris is the gainer, otherwise a loser. The authorities, therefore, see to it that the work is economically conducted to keep down the interest charges, and that routes are selected which will return heavy traffic receipts. So far the results have shown a profit to the city of Paris.

In Boston the system of subways was constructed admittedly to accommodate the cars and trains of the company owning the surface and elevated lines. After the work of construction was completed, under the direction of an honest and capable board, it was leased to the railroad company at a rental of four and one-half per cent on the actual cost. As Boston can borrow money at a considerably lower rate, this return is sufficient to repay interest and allow for depreciation and a small profit, besides developing the city.

In New York the law provides that a contract shall be offered to public bidding, and that the contractor shall be paid by the city the amount bid by him for construction, and that he shall then operate the railroad for a period of years, paying as rental such interest on the cost as the city pays, and in addition one per cent as a sinking fund. Although differing in details, the plans of Paris, Boston, and New York have in common the general principles of ownership by the municipality, and thereby the retaining of control of the public streets. The terms fixed by these three cities are moderate, being at most little more than interest on cost, and as such tend to invite capital to embark in the building of these railroads. Such development is the prime object, and not municipal profit. In following the examples already set, other communities will do well to pattern closely and not impose burdens that will hinder rather than assist.

In studying the problem for the building of a new line or the reconstruction or extension of an old one, the engineer should be sure he understands all phases of the question. While it is his business to supply the public with the facilities that the public desire, and not what he thinks they should desire, nevertheless he must be sure that there is sound and permanent logic in public demand. The traffic routes should be analyzed to determine the trend of travel and reasons for it. Frequently arguments are advanced that railroads should not be built along congested streets, because they tend to increase congestion, but instead they should be built along other and less frequented streets so as to draw travel away from the congested routes. Travel is usually concentrated along certain routes for well-established reasons, and frequently in spite of lack of transportation facilities. In this case it is idle to talk of drawing travel away. People that have become set in certain ways are hard to change, and a line built off a line of travel is of little public benefit and is doomed to failure or to a long wait for business to originate before attaining success.

People also wish to be carried quickly. As our cities grow and distances increase, this question of speed becomes more and more important, as people measure the distance by minutes occupied in travel. Railroads for rapid transit should, so far as possible, be on straight lines, and if one straight line cannot reach all the desired points, then other railroads must be built as soon as business warrants. The mistake should not be made of sacrificing the best individual results in the attempt to partially satisfy many. These were the errors in the location of the first underground railroads in London, where the attempt was made to avoid congested routes and give a circuitous location.

The general type of the railroad to be built will also require careful consideration, whether elevated or subway, whether shallow or deep. Here one must be careful not to draw hasty conclusions that, because a certain type or method of construction has succeeded in one place, it will succeed equally elsewhere. This mistake was made in Brooklyn and Chicago after the initial success of the elevated railroad in New York. Then when once a type and general design have been adopted as best suited for the locality under consideration, the engineer must be on his guard not to be so closely wedded to his design as to fail to recognize when to vary it or even when to depart entirely. The New York subway is called an example of shallow construction, that is, as close to the surface of the street as possible, and so it is, for such was the motive of the design to be followed as much as practicable. Yet of the 24.7 miles of which it is composed, 5.7 miles are elevated, 1.4 miles are in iron-lined tubes, 3.4 miles in deep tunnel, 1.2 miles in arched construction, and only 13 miles, or but little more than one-half of the whole, are of typical shallow construction, with a flat roof of steel and concrete construction. These changes were made for local topographical reasons, whereby better operating results were obtained.

In laying out rapid transit lines, it is found that people will not walk far to reach even a superior means of transportation, but are inclined to take the first at hand. For this reason one such road will not serve a very wide belt of territory, and the danger of disadvantageous parallel competition does not exist in anything like the same degree as with ordinary railroads operating in the same territory. New facilities of this character create their own traffic. The chief question arising is whether any particular route possesses in itself sufficient possibilities to justify the expensive construction. As parallel competition is not to be much feared, so new lines, even of an opposition corporation, should always be so constructed as to be capable of physical connection to permit through running. The whole tendency of American experience is toward consolidation of a city's transit lines. As a matter of fact, the public are better served when all lines are thus gathered together as a monopoly, and thus give the people the benefit of through running or of transfer.

In this respect the city of Paris has set a wise precedent in creating a single private corporation to which are to be awarded all the rapid transit lines as fast as built. The municipal authorities there have thus boldly prevented any so-called competition, and have even organized a private monopoly. On the other hand, they have secured the certainty of operation of lines which, independent, would not pay to operate, thus affording means of rapid travel to all parts of the city, and have secured for the inhabitants the privilege of making any journey in any direction of even the greatest distance for a single fare.

London, on the other hand, is an illustration of the opposite plan. Of the six tube railroads now built or building, there are five different sizes calling for entirely different standards of equipment; so that, if ever these lines should come together under a single management, uniformity of management and physical connection are out of the question. Even with the surface lines, some of which are owned and operated by the London County Council, and others by private corporations, antagonism is so great that physical connections are prohibited, and necessary extensions of private lines prevented, thus making passengers change cars and actually depriving the public of much-needed facilities. In these two great cities we see, on the one hand, monopoly working smoothly for its own advantage and the public benefit, and on the other competition existing to the point of general injury, public as well as private. So acute have become the London conditions that the British government has had in existence for two years a royal commission studying the problem, with a view of proposing some remedial measures.

In judging of the value of traffic routes, two chief considerations must be kept in mind. First, mere density of population does not of itself signify great traffic returns. A certain portion of the population of great cities, and usually that which is densest, is not migratory, but being clustered around its work has little cause to go to other parts of the city. On the other hand, there are neighborhoods where the population is more sparse, but where the residents leave their homes for business, shopping, visiting, school, and entertainment. One must differentiate therefore between traveling and stationary population. This is well illustrated in New York, where one of the elevated lines traverses the celebrated tenement-house district, where more people live per acre than in any other city of the world. The traffic returns are very low. Other portions of the line traversing districts where the population is not one-tenth of the former show receipts several fold greater. Second, special points of occasional crowding are not so productive of traffic as they would seem to be. Recreation grounds and parks used occasionally or on certain days or seasons are illustrations, and even terminal stations of great railroads. To again quote from New York experience, when it is remembered that the Manhattan elevated and subway systems alone, on but a little over fifty miles of road, carry two-thirds as many passengers as do the steam railroads of the United States on over 200,000 miles, it needs no demonstration to show that the number of passengers interchanged with the Grand Central Station, the terminus not only of the New York Central system, but of the New England railroads as well, does not constitute a large percentage. Even in London, where the facilities are inferior to an American city, the board of engineers in their report advising the royal commission above referred to, show that one trolley terminus where the lines, through opposition, are compelled to stop short of ultimate destination, discharges and receives more passengers than are similarly handled at six large railroad passenger stations combined. A street passing through a commercial or shopping district, with places of entertainment in the neighborhood, is a much more desirable district to reach from the point of financial return, and more necessary from the point of view of public convenience, than the greatest railroad terminus or most popular ball ground.

THE USE OF COPPER IN DESTROYING TYPHOID ORGANISMS, AND THE EFFECTS OF COPPER ON MAN.

IN the American Journal of Pharmacy, Henry Kraemer excellently discusses the effects of water treated with copper on man. His conclusions may be summarized as follows:

1. It is pretty well established that the typhoid organism is disseminated not only through water, but also through air and food, and may retain its vitality for a considerable period of time.

2. Typhoid organisms in water are eliminated by filtration, boiling, and certain biochemical methods. Of the latter, the use of copper, as proposed by Moore and Kellermann, is probably the most efficient and at the same time most practicable.

3. While exceedingly minute quantities of copper in solution are toxic to certain unicellular organisms, as bacteria, it is safe to assume that the higher plants and animals, including man, are unaffected by solutions containing the same or even larger amounts of copper.

4. There being a number of factors which tend to eliminate copper from its solutions, it is hardly likely that there would be any copper in solution by the time the water from a reservoir reached the consumer if the treatment of the reservoir were in competent hands.

5. Many plants contain relatively large quantities of copper, and when these are used as food some of the copper is taken up by the animal organism, but there are no records of any ill effects from copper so consumed.

UTILIZATION OF TIDAL POWER.*

By JAMES SAUNDERS, A.M.Inst.C.E.

THE report of the Royal Commission on Coal Supplies has made it clear that in the future England will have to generate power by other means than from coal if she is to keep her place as the foremost manufacturing nation in the world. It is true there is no immediate hurry for this, seeing that there is an estimated quantity, in the proved and unproved coal fields of the country, of about 140,000 million tons of that fuel yet to be mined. The present annual output is about 230,000,000 tons, and for the last thirty years the average increase in the output has been 2½ per cent per annum. If the same rate of increase continues in the future, in four hundred years our available coal supply will be exhausted, but long before this time arrives—if coal is to remain the only means of generating power, heat, and light—this country will be dependent on other markets, and the price of coal will prevent us from being a competing nation for the world's commerce.

The discoveries and inventions that have taken place during the preceding century leave no doubt that some force of nature will be adapted and made subservient to man's dominion, so soon as the pressure of the enhanced price of coal is felt.

The sources of power within the bounds of possibility of utilization at the present time appear to be water-falls, direct heat of the sun, the interior heat of the earth, and winds.

In the British Isles, according to Prof. Forbes, there are only a few places where over 1,000 horse-power can be developed from waterfalls, and he estimates that the total saving in coal which might be effected by the use of all our available water power to be about 1,200,000 tons per annum, which is equal to about 150,000 horse-power working ten hours per day. At the present time there is about 12,000 horse-power being generated by hydraulic electric plant in England.

The utilization of the direct heat of the sun cannot be successfully carried out in this country owing to the climatic conditions, and at the present time there is no possibility of the interior heat of the earth being utilized. The largest wind-power generator in existence does not exceed 60 horse-power, and energy derived from this source is so uncertain and fluctuating that it is hopeless—until a cheap means of power storage is invented—to utilize this force so as to be of any great advantage to the community.

There are a few small schemes for the utilization of tidal power in existence in the British Isles, the plan generally adopted being to impound the rising tide in a pond or reservoir, and, on its ebb, utilize the power by water-wheels. This does not give a constant power, and is only available during the ebb of the tide, thus making the hours of work governed by the lunar instead of the solar day. There is no doubt that this would be a serious obstacle to the success of any scheme if it could not be overcome. M. Decœur, a French engineer of some repute, has propounded a system which overcomes this difficulty to a great extent, and the following schemes are an attempt to adapt his principles to three places in this country.

* Engineering Review.

Before discussing the schemes in detail it would be as well to look into the question of rise and fall of tides upon our coast. The tidal fluctuations are governed by the moon. On the west coast of Ireland and the south coast of England the highest tides occur

MEAN LEVEL HIGH WATER ORDINARY SPRING TIDES
MEAN LEVEL HIGH WATER ORDINARY MEAN TIDES
MEAN TIDE LEVEL
MAXIMUM TIDE
MAXIMUM TIDE
MEAN LEVEL LOW WATER ORDINARY MEAN TIDES
MEAN LEVEL LOW WATER ORDINARY SPRING TIDES

FIG. 1.—DIAGRAM SHOWING VARIATION IN HEIGHT OF TIDES.

three transits after the new and full moon, and along the east coast of England they take place four transits after the new and full moon, and in the River Thames five transits occur in the same epoch; these times being regular unless diverted by gales or wind or other extraordinary causes.

The period that elapses between the tides is about twelve hours and twenty-four minutes, and as the moon takes twenty-seven and one-third days to travel round the earth, there are two points, one when it is in a line with the sun, and the other when on the opposite side of the earth to the sun, that the tides are at a maximum, the points equally distant between these times being the places when the tides are at a minimum, as shown in Fig. 1. The height of the tides varies considerably along the coast, being greatest on the Bristol Channel, where they have a maximum elevation between high and low water of 50 feet, and the following table gives a few of the places upon the coast of the United Kingdom showing the rise in feet at spring and neap tides.

To utilize this variation of height between high and low tide it is necessary to inclose a considerable area of tidal water, which must again be divided into high- and low-water basins. This, of course, under ordinary conditions would be extremely expensive on account of the necessity of building massive dams to inclose the areas; therefore if a financially successful scheme is to be undertaken, the natural configuration of the coast must be taken advantage of, so as to reduce the cost of building the dams to the least possible amount. This is well illustrated by Fig. 2, which shows a tidal scheme for Chichester harbor, and it will be seen that by building a main dam across the entrance to the harbor, 1,300 lineal yards in length, 7,380 acres of tidal water would be impounded. This dam should be of almost breakwater proportions, as shown in Fig. 3, and to admit the tidal water into the high-water basin, and discharge it from the low-water basin, large sluices worked from the power house by means of electric motors should be erected, so that the operator in charge could regulate the admission and discharge of the tidal water, the height of which would be constantly under his observation by means of a tidal gage fitted on the switchboard. The dam should also be provided with locks having sea gates in addition to the ordinary gates, each of the locks being of sufficient capacity to admit the largest vessels likely to use the harbor. The dam could be cheaply constructed in cement concrete; a clean shingle, very suitable for this purpose, being readily obtainable on the harbor bar for the cost of dredging.

Place.	Springs. Feet.	Neaps. Feet.
Penzance	16¼	12½
Plymouth Breakwater	15½	12
Cowes	12½	9½
Selsea Bill	16½	12½
Folkestone	20	16½
London Docks	20¾	17¼
Yarmouth	6	4½
Spurn Point	18¾	15
Tyne River entrance	15¼	10¾
Aberdeen	12	10
Glasgow	11¼	9¼
Morecambe	27	21
Falmouth	16	12
Portland Bill	9	6½
Southampton	13	9½
Brighton	19¾	16
Dover	18¾	15
Harwich	12¾	10½
Boston deep	22	15 1-3
Scarborough	15¾	12½
Queen's Ferry	18	14
Oban	13	9½
Douglas	20¾	16
Liverpool	27½	20¼
Aberystwith	14¼	10
Portishead	42	33
Newport	38	29
St. Ives	21	15

The harbor would be divided into nearly two equal halves (one being the high-water basin, which would be filled by the rising tide, and the other the low-water basin, emptied on the ebb tide), by a powerhouse and a dam, a portion of which could be constructed in a somewhat similar manner to that shown in Fig. 3, a further portion of a design as shown in Fig. 4 being formed of excavated materials from the low-water basin protected by means of a concrete facing.

Fig. 5 is a plan of the main dam across the entrance to the harbor, showing the locks and power house, and Fig. 6 is an elevation of the same—the vertical and horizontal scales having a ratio of 10 to 1 respectively—showing the position of the sluices on the face

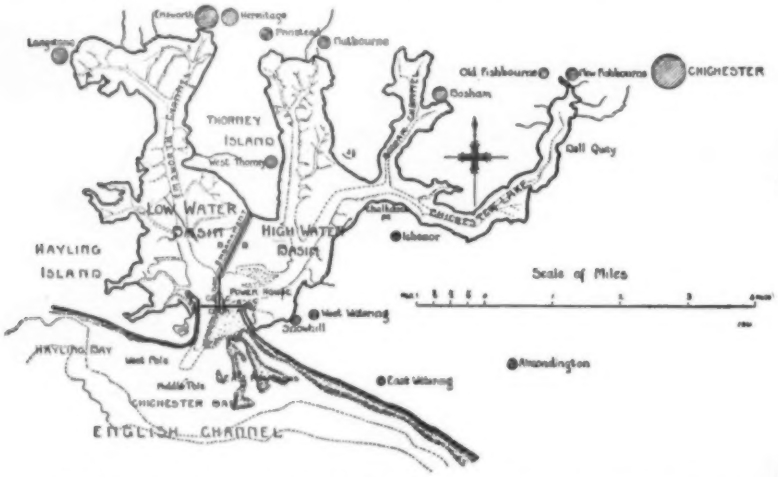


FIG. 2.—PLAN OF CHICHESTER HARBOR, SHOWING TIDAL POWER SCHEME.

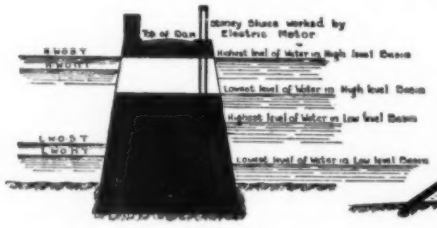

Top of Dam
Storey Sluice worked by Electric Motor
Highest level of Water in High level Basin
Lowest level of Water in High level Basin
Highest level of Water in Low level Basin
Lowest level of Water in Low level Basin
HIGH WATER
LOW WATER

FIG. 3.—SECTION THROUGH DAM, A A.

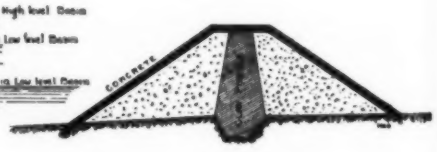


FIG. 4.—SECTION THROUGH EMBANKMENT AT B B.

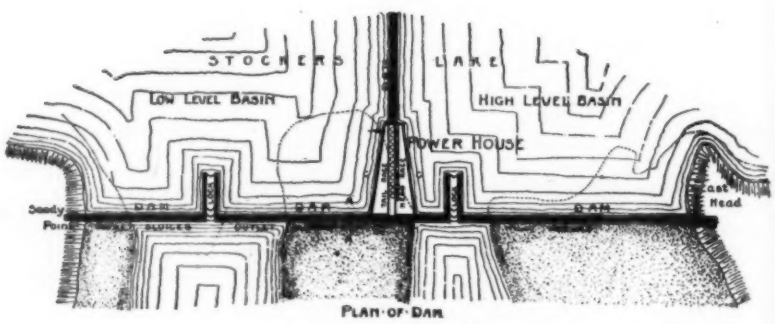


FIG 5.

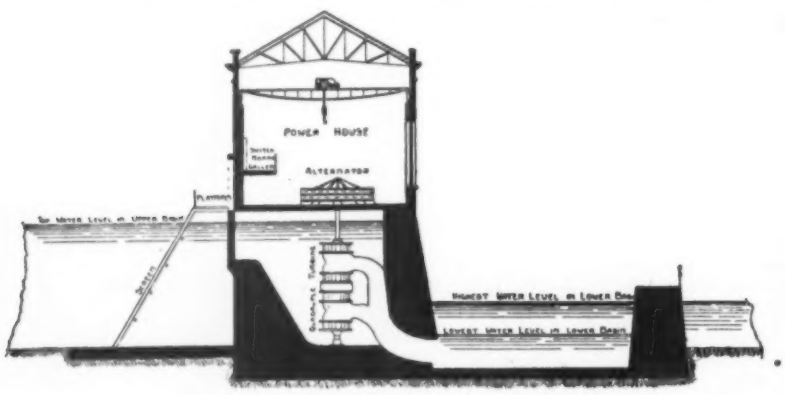


FIG. 7.—SECTION THROUGH POWER HOUSE, C C.

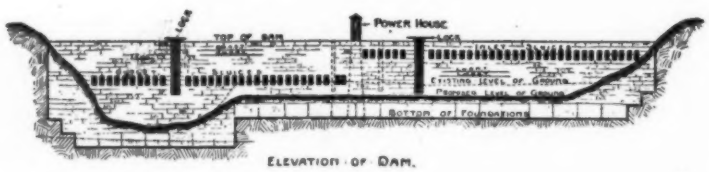


FIG. 6.

CHICHESTER HARBOR TIDAL POWER SCHEME.

of the dam. A section through the power house is shown in Fig. 7, and it is suggested that quadruple turbines, each 800 E. H. P., should be installed, driving directly three-phase alternators, but these details of the electric hydraulic plant will be discussed in a general manner further on in this article.

The power that could be obtained from this installation at the lowest neap tides would be 6,800 E. H. P. per day, constantly for the whole of the twenty-four hours; in addition to this during the spring tides there would be at the maximum an additional 7,000 E. H. P. for 10 hours per day, the time that this would be available being governed by the lunar day, so that on the average there would be about 8,000 E. H. P. per day to be disposed of.

It may be fitting to here inquire as to what is the worth of this power. The Niagara Falls Power Company, after a very careful consideration of the subject, came to the conclusion that 24 hours' steam horse-power is not produced anywhere in the world for less than £5 per year, and that this price does not represent more than one-half of the total cost of the production of power. This would practically mean that, allowing for loss of power through the inefficiency of the machinery, an electrical horse-power would be worth about £7 per annum. The County of London and District Electrical Power Company are proposing to supply works using power for eight hours or over per day at the rate of 0.865d. per unit; this for a working week of 50 hours amounts to £9.4 per annum. The two most economical electrical power stations in the United Kingdom are Glasgow and Newcastle-on-Tyne, and the following table shows the cost in pence per unit of current generated:

	Glasgow.	Newcastle-on-Tyne.
Coal	0.15	0.16
Oil	0.03	0.02
Wages	0.13	0.13
Repairs	0.10	0.13
Total costs	0.41d.	0.44d.

Taking a 24-hour day of the most economical of these stations, the total works cost amounts to £14.9 per E. H. P. per annum, and for coal alone the cost is £5.475.

In hydraulic electrical stations the power can be produced in some cases to sell as low as £2.4 per E. H. P. per annum, and at Niagara, according to Prof. Forbes, power is being supplied at the rate of £3.6 per E. H. P. per annum, on a capital outlay of £45 per E. H. P., or at the rate of 8 per cent on the outlay, which includes working expenses and capital charges. This small charge is not to be wondered at when it is known that the operating expenses on 45,190 E. H. P. did not exceed £25,000 per annum for the whole of the output.

If £4.5 were charged per annum per E. H. P. for a 24-hour day, in this country it must be considered a reasonable price, in view of the foregoing particulars, and it would be much less than any manufacturer can now produce steam power for. Speaking generally, it has been ascertained that hydraulic electrical power schemes are a financial success where the interest, depreciation, working, and maintenance expenses do not exceed 12 per cent of the capital expenditure. Therefore the schemes dealt with here will be judged on this basis.

Reverting again to the Chichester harbor scheme, this gives for an average output of 8,000 E. H. P. a yearly income of £36,000, which would justify a capital expenditure of £300,000.

A scheme for utilizing the fluctuation of the tides in the Menai Strait has several advantages over the preceding scheme, and is shown in plan by Fig. 8. Firstly, there is a variation in the height of the tides at Beaumaris and Carnarvon Bar, the points selected for the entrance and emission of the water. At Beaumaris the rise of the spring tides is 23 feet and at the neap tides 16½ feet, and on Carnarvon Bar the rise is 15¾ feet at springs and 12 feet at neaps. Secondly, there is also a variation in the time of high water at each place amounting to about an hour. Fig. 9 shows a diagram of the neap tides plotted out to show both the admittance of the water into the high level basin and the discharge of the same from the low water basin. On this diagram the dotted line *A B* shows the point of minimum fall, which is 7 feet, the maximum fall being at *C D* of 11 feet in height, the average fall throughout the tide being 9 feet, the shaded portion of the diagram showing the fall available at all periods for the production of power. The area of the inclosed basin is 6,500 acres, and the total effective electrical horse-power available at neap tides being 13,500, this being increased by a further 15,500 E. H. P. at spring tides. There would be a dam 2,600 lineal yards long, shown in cross section in Fig. 10, to construct at Beaumaris, the dividing dam between the two basins, 890 yards long, being built at Llanidan, and at Carnarvon Bar a dam 490 lineal yards long would be built to separate the low-water basin from the outer tidal water. All of these dams would be provided with locks, so that the shipping traffic on the various ports on the Strait would not be interfered with. There are in this case two small rivers discharging into the low-water basin, and if the full effective power of the tidal fluctuation is to be taken advantage of, these should be diverted directly into the sea, otherwise the discharge of their contents would fill up a considerable space in the low-water basin, which should be kept entirely for power purposes. On the south side of Carnarvon Bar it is proposed to dam a small portion off in lieu of diverting the streams, and utilize this power through turbines on the fall of the tide. The main power house is proposed to be placed on the central dividing dam, and is shown in plan in Fig. 11 and in elevation in Fig. 12. Quadruple turbines would generate the electrical energy, which would be distributed to the various towns and districts in the vicinity.

The averaged power daily available would be 14,500 E. H. P., which, calculated of the same value as before, would amount to £65,250, a sum sufficient to pay interest, depreciation, working, and maintenance expenses at the rate of 12 per cent on a capital expenditure of £543,750. It may be questioned as to whether this amount is sufficient to erect the works under consideration, and it will be as well to go more closely into the estimates of cost of this scheme, which have been carefully worked out as follows:

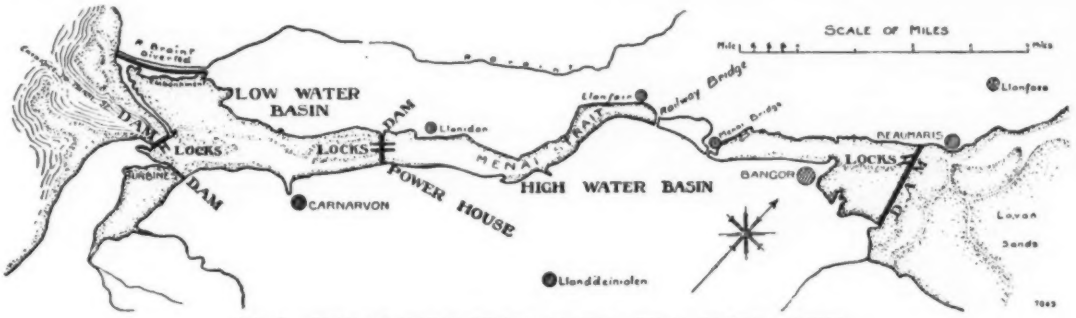


FIG. 8.—PLAN OF MENAI STRAIT, SHOWING TIDAL POWER SCHEME.

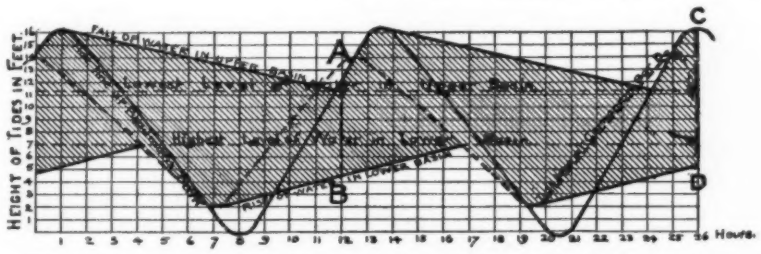


FIG. 9.—DIAGRAM SHOWING RISE AND FALL OF TIDE AND LEVEL OF WATER IN HIGH AND LOW WATER BASINS.

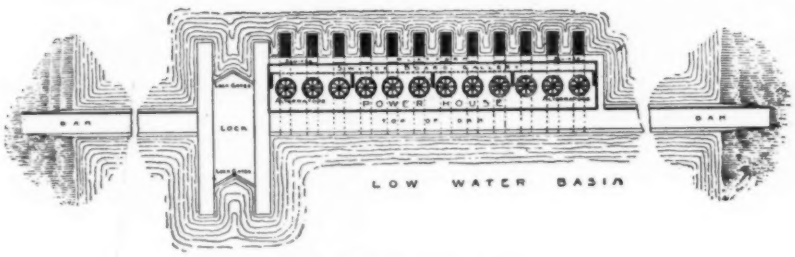
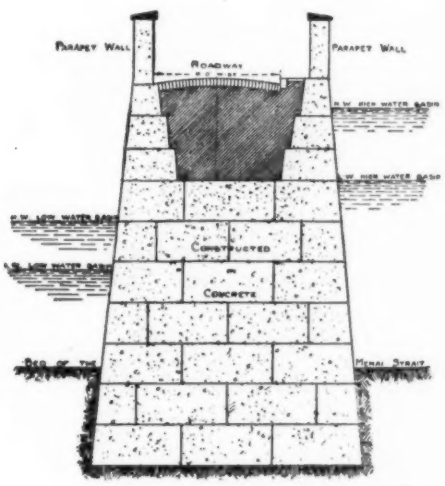


FIG. 11.—PLAN OF POWER HOUSE.



SECTION THROUGH DAM

FIG. 10.

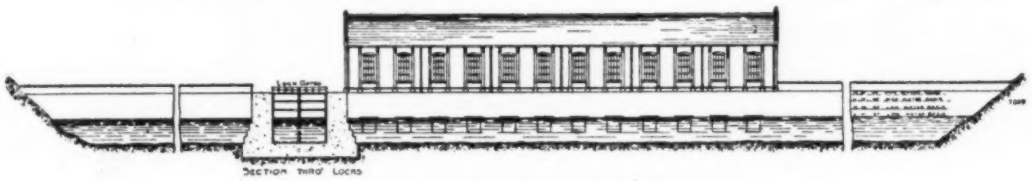


FIG. 12.—ELEVATION OF POWER HOUSE.

MENAI STRAIT TIDAL POWER SCHEME.

MENAI STRAIT SCHEME.
Estimate of Cost.

Lin. Yards.		£	£
2,600	Dam across Straits at Beaumaris	65	169,000
490	Dam across Straits at Carnarvon Bar	60	29,400
890	Dam across Straits to divide high and low water basins	30	26,700
	Locks	—	30,000
	Power house	—	22,000
	Sluices	—	7,000
	Turbines	—	95,000
	Alternators, switchboard, and other machinery	—	55,000
	Cable line and transformers for distribution of power	—	30,000
	Diverting rivers	—	3,000
	Promotion expenses, engineering fees, contingencies, etc.	—	75,000
	Total		542,100

A more ambitious scheme for the utilization of tidal power is the one shown in Fig. 13, which is a

scheme for the conversion into useful power of a portion of the enormous amount of energy of the tidal waters of the Bristol Channel. The Welsh grounds are proposed to be inclosed with a dam to form the low-water basin, the high-water basin being made by damming up the mouth of the river Severn. This has one great advantage, as the whole of the fresh water flowing down the rivers Severn and Wye, whose

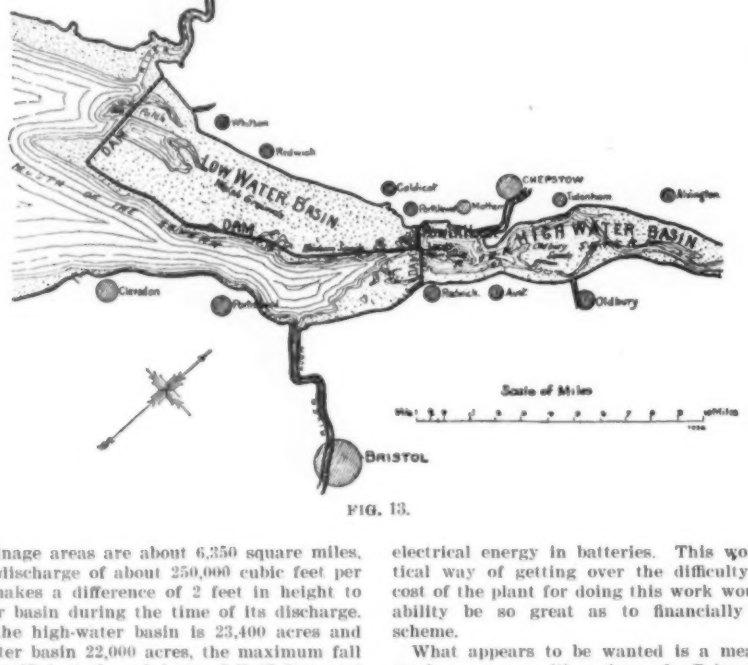


FIG. 13.

combined drainage areas are about 6,350 square miles, is equal to a discharge of about 250,000 cubic feet per minute and makes a difference of 2 feet in height to the high-water basin during the time of its discharge. The area of the high-water basin is 23,400 acres and of the low-water basin 22,000 acres, the maximum fall available being 25 feet, the minimum fall 17 feet, and the averaged fall for the whole of the twenty-four hours being 20 feet.

This gives 240,000 E. H. P. for the whole of the twenty-four hours at neap tides and a further 300,000 E. H. P. for ten hours per day, available only on the ebb of the tides, during the maximum spring tides, which would be equal to an averaged daily E. H. P. of about 21,000. It must be admitted that there is a difficulty of dealing with this semi-menstrual increase of the amount of power by any known means that would be at all economical both from a financial and engineering point of view. Briefly reviewing the means at present available for storing this surplus power and using when required, they may be put down as follows: (1) Converting the energy into compressed air, storing and reconverting to energy when required by using the same through air motors. The objection to this is the large capital cost and the great loss in the conversion and reconversion. (2) The surplus energy might be pumped up into a high storage reservoir, and afterward the stored water be passed through turbines, thus reconverting the energy of the stored water into power. The same objections apply in this case as to the last, only perhaps not quite to the same extent, as there would not be the same amount of loss in conversion. (3) Storing the electrical energy in batteries. This would be a practical way of getting over the difficulty, but the first cost of the plant for doing this work would in all probability be so great as to financially condemn the scheme.

What appears to be wanted is a means of cheaply storing energy with a loss of efficiency on the process of conversion brought down to the minimum. It may be that a brilliant genius will some day evolve out of oblivion a process for doing this. If a simple means for the electric decomposition of water could be perfected it might meet the case, for the oxygen liberated would be available for many purposes and would be a marketable commodity, while the hydrogen would be stored in huge gas holders and used for heating purposes. It is, however, clear that unless some advance is made on the present imperfect appliances for the storage of energy, the variable tidal flow from the maximum to the minimum of the spring tides could be made of very little use.

In the Bristol Channel scheme, assuming the energy to be worth £4.5 per E. H. P. per annum, it would realize the enormous sum of £1,170,000 per annum, which would justify an expenditure of £9,750,000.

Coming to the more general details of the work, the lower-house would be placed on the dam dividing the high-water basin from the low-water basin, and means would be provided so that, during the ebb of the tide, the water from the high-water basin could be run direct into the river Severn channel without passing the same through the low-water basin, so that the fresh water coming down the Severn and Wye rivers could be fully utilized. The dams to the high-water and low-water basins would each be designed with a sufficient number of sluices to admit and discharge the contents of the basins at the same rate that the tide ebbs and flows. It would be necessary to provide locks for the shipping traffic to the upper basin but not to the lower basin, and by doing this the shipping industry would not be materially interfered with, as at the present time in order to reach the upper ports of the Severn it is necessary to pass through a number of locks. The impounded waters of the high-level basin would form a natural dock whose rise and fall would be only 10 feet. This would materially enhance the prosperity of the ports up this part of the river, the small fluctuations in the height of the water compared with what at present exists being all to the advantage of the shipping.

The Dutch, who have had some considerable experience in damming back the waters of the sea for some centuries, have solved the problem of constructing earthen embankments for this purpose in a cheap manner, and their designs of dams could be followed with safety; but there are reasons for departing from the earthen embankment for inclosing the basins under question, and it remains to be seen whether futurity will not be able to construct a durable dam in a cheap and economical way. Figs. 16 and 17 show a suggestion on this, being the cross section and plan respectively of a portion of the dam proposed for the Bristol Channel scheme. It is proposed that the dams should be constructed in ferro-concrete, the framings, which are well braced together, being all made on the land, floated out, and raised and fixed in position by means of "Titan" cranes working from the top of the portion of the embankment already finished. All that would then be necessary would be to drive in the side piles and affix the cross ties, the interior of the embankment being formed of hard excavated matter dredged from the low-water basin. Such a dam should be very cheaply constructed, and could be made sufficiently strong to resist the forces brought to bear upon it.

In all schemes for the utilization of tidal power which can be discussed at the present time, the most important point must be the question as to whether they can be made to pay or not. The success of the Niagara hydraulic installation has shown that, provided cheap power can be produced, there is every reason to believe that the enterprising manufacturers in a country will remove their factories to the vicinity, but we have now, in addition to this, the means of taking energy with very little loss of power over immense distances, so that instead of Mahomet coming to the mountain the mountain will go to Mahomet. Looking at the Bristol Channel scheme from this point of view, it will be seen that it is situated in the center of a populous district, being able to command

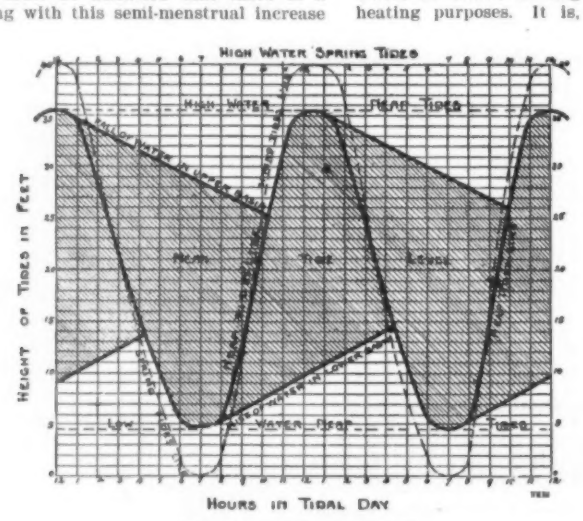


FIG. 14.—TIDAL DIAGRAM.

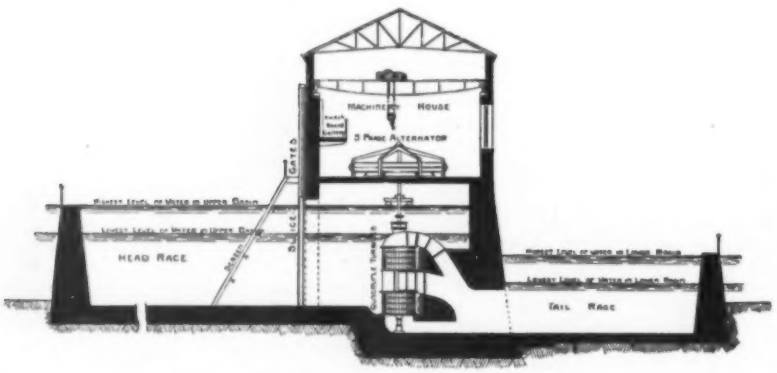
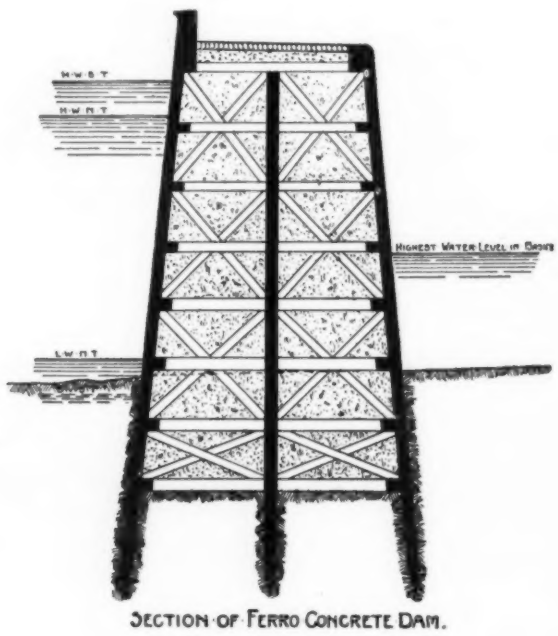
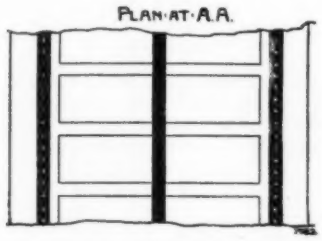


FIG. 15.—SECTION THROUGH POWER HOUSE.



SECTION OF FERRO CONCRETE DAM.



FIGS. 16 AND 17.

BRISTOL CHANNEL TIDAL POWER SCHEME.

such towns as Bristol, Cardiff, Newport, and all the large and populous South Wales towns, as well as Gloucester, Cheltenham, Bath, and Chepstow—a district favorable for disposing of energy on account of there being an accumulation of trades due to the coal fields of South Wales.

The following is an approximate cost of constructing the Bristol Channel scheme. It has been prepared without a detailed survey being made, but will be somewhere near the actual cost, and it may be compared with what is set forth as the limiting expenditure on capital that should be made to make the scheme a financial success:

BRISTOL CHANNEL SCHEME.

Estimate of Cost.

Lin. Yards.		£	£
32,600	Main dam inclosing low water basin	150	4,890,000
3,960	Main dam across mouth of the Severn	150	594,000
	Locks, 1 set	—	50,000
	Sluices	—	100,000
	Power house	—	200,000
	Turbines	—	1,500,000
	Alternators, switchboard, and other machinery	—	1,000,000
	Cable for distribution transformers, etc.	—	300,000
	Promotion expenses, engineering fees, contingencies, etc.	—	900,000
	Total		9,534,000

One of the main difficulties until comparatively recent times for any scheme of this kind has been the difficulty of the conversion of the flow of the water into energy and its distribution. This has occurred because the height of the water in tidal schemes is constantly varying, the falls being low and the maximum head, compared with the minimum head, being great when considered with the height of the whole fall. Recent hydraulic installations have, however, shown us that these difficulties can be overcome, and large units, efficient both at full head and when running at the smallest head, can be built and kept at a speed sufficiently constant to drive alternators for generating the power. It will be instructive to quote a few of these.

At Cusset, on the Jonage Canal near Lyons, eight double turbines each of 1,500 horse-power are working on a fall varying from 26 to 33 feet, at a speed of 120 revolutions per minute. The turbines are directly coupled to horizontal alternators, and are regulated by means of oil pressure governors. The hydraulic electrical power station at Schaffhausen, one of the pioneer large plants erected in the world, is now well known, and under a fall varying from 11.5 to 14.8 feet, the turbines generate 350 horse-power, the efficiency at full gate being 86.6 per cent, at three-quarter gate 82.6 per cent, at two-thirds gate 84 per cent, and at one-half gate 77 per cent. On the bank of the Rhine there is a large installation of hydro-electric power generating plant at Rheinfelden, consisting of twenty sets of quadruple turbines of 840 horse-power each directly connected with the electrical generators. The speed of the turbines and generators is 55 and 68 revolutions per minute, the minimum fall being 10 feet 6 inches and the maximum fall 16 feet. The turbines have a commercial efficiency of 75 per cent, and as the head of water varies so much, they have been designed so as to give a constant power. The alternators generate three-phase current at 3,800 volts, and the total losses on the power distribution plant from the turbine shaft to the factory motor has been found to be 32 per cent. An interesting installation has been erected at Chevres, where under a minimum fall of 14 feet, 1,200-B. H. P. turbines have been erected running at a speed of 80 and 120 revolutions per minute, the electrical machinery being driven direct. Five of the turbines are of the double cone pattern, and ten are designed as centrifugal turbines.

Mr. Alphonse Steiger, in a paper recently read before the Institution of Civil Engineers, stated that a large scheme was under consideration for the installation of units of 1,400 B. H. P. under a fall of 10 feet, running at 66 revolutions per minute. Considering the above accomplishments of the manufacturers of turbines, there seems little doubt that they will be able to rise to the occasion of building generators suitable for the small and varying falls obtainable in tidal power works.

Generally speaking, the turbines must be designed as vertical multiple machines on the same shaft, so that the electric generators can be directly connected thereto. The speed must be kept as high as possible, but in the case of large generators it may be as low as 55 revolutions per minute, as at that speed the alternators can be driven direct.

In making calculations throughout for the three schemes mentioned herein, allowance has been made in all cases for the loss of fall in the high- and low-water basins, due to the sloping of the sides of the banks, and the following efficiencies for the plant have been assumed; the turbines to have an efficiency of 75 per cent, the efficiency of the generators being taken at 90 per cent, and the loss of efficiency in distributing the current at 5 per cent.

In conclusion it may be said that the author has merely touched the fringe of the subject and tried to point out that the utilization of tidal power is not such a fantasy as many people imagine.

There are many difficulties to be overcome before a scheme could be brought to a successful conclusion, but as the world's experience of different engineering works increases year by year, so much nearer is the time brought when light, power, and heat will be generated by other means than the combustion of coal. The manufacturing city, now one of eternal smoke and vitiated atmosphere, will then become the city of health, light, and cleanliness.

NOTES ON THE INDUCTION MOTOR AS A GENERATOR.*

By T. P. E. BUTT.

IT has been known almost from the initial invention of the asynchronous alternating motor, generally known as induction motor, that, if connected to its supply mains and driven at a slightly higher speed than synchronism, it reverses its usual function and becomes a generator. This knowledge, however, does not appear to have been put to any extensive use, at least not in a commercial sense,† and even in cases where applied, very few details are obtainable to allow one to form an opinion of the actual value of such machines.

There is another point in such machines equally interesting, and perhaps more useful, demonstrated by Danielson, and published in the Elektrotechnische Zeitschrift about two years ago. He described a method of converting an alternating-current motor from asynchronous to synchronous, by suitably exciting the rotor with continuous current. This is a point for which much use should be found, for such machines, in addition to possessing the inherent qualities of the synchronous motor, are self-starting. In order to effect this the motor is started up as an induction motor on light load, so that its speed approximates synchronism. At the right moment the rotor lines are switched over from the resistance to a suitable source of continuous current, which pulls the rotor into synchronism, and maintains it at this speed. Such machines should be of use on inductive systems to raise the power-factor, where such an inflexible arrangement as the ordinary synchronous motor may not find favor.‡ Circumstances having placed the writer in a position to test the above principle, he assumed that the converse would hold good—that is, if power were applied to the rotor shaft, and its windings supplied with continuous current, the outcome would be a successful generator. The results are given in this paper, and, although not obtained under favorable conditions, are of interest.

About two years ago, when it was decided to augment the lighting supply of Johannesburg from the electrical plant of the Robinson Deep Gold Mine Company, it was found necessary to obtain an additional generator to provide a reserve for the existing plant, in case of accidents and to allow for general repairs. The management did not at first fall in with this idea, and the project temporarily fell through. It happened, however, that a 300-horse-power, 2,000-volt induction motor, originally intended for operating a hoist, had been lying dismantled on the property for several years, and the suggestion of the writer to convert this into a generator was entertained and adopted. It should be explained here that the generating plant consisted of two direct-coupled, three-phase, 250-kilowatt machines working at 2,100 volts, 60 cycles, and the power demand was such as to require one generator constantly running, the second assisting on the peak of the load for several hours during the day, while from 4:30 P. M. till midnight this second generator was loaded and often overloaded for the municipal supply, and although in case of accident to either generator the mine requirements would have had first consideration, the town supply was sufficiently remunerative to warrant the installation of another machine. Owing to the difficulty in getting at short notice an engine suitable for driving this machine, it was arranged to operate it from one of the mill engines, a 500-horse-power, single-crank, compound engine having at that time a surplus of about 300 horse-power. A friction clutch and pulley were attached to an extension of the line shafting and rope-drive provided. This necessitated the location of the generator in a wing at the extreme end of the power-house, in a position invisible from the main switchboard.

To use the generator synchronously involved very little alteration to the existing apparatus. The windings, of course, remained the same, but it was necessary to make provision for a variable speed for this machine, which, unlike the ordinary generator, requires a slight increase of speed to take an increased load. To get a variable speed from the mill engine was out of the question, and recourse had to be made to other means, viz., magnetic slip. This demanded the installation of the huge rheostat which originally formed the controller. This method would not be an efficient one if constantly used, but this was not intended, its use being restricted, as a rule, to the short period of time required in putting in or taking out of parallel with another generator to regulate the transfer of load. This arrangement demanded a permanent increase of speed above that of synchronism, and an increase of 5 per cent was allowed, which was as much as possible, taking independent working into account. The controller was located near the generator, and operated by motor from switchboard, the position of its axle being indicated by luminous signals. The arrangements for asynchronous running were practically complete, but for independent working an exciter was required suited to the rotor winding, and for this purpose a disused plating dynamo was found having a capacity of 600 amperes at 30 volts. A low-tension panel was located near the generator, and the rotor windings brought to it, provision being made for rapidly connecting them to either the exciter or controlling rheostat.

It may be opportune at this point to give a short non-mathematical explanation of the action of asynchronous generators, which differs in some points from that of the regular generator, and is not generally understood by practical men. Taking the ordinary polyphase induction motor, here we have a shifting magnetic field in the stator, as a resultant of the combined action of the primary currents. The torque on the secondary (usually the rotor) due to currents generated in its conductors by cutting this flux, is proportional up to a certain limit to the difference in the relative speeds of the primary flux and the revolving element, and is practically proportional to the load. Beyond this limit the torque starts to fall off, owing to magnetic leakage caused by the heavy currents in rotor and stator, and if the load is not reduced the rotor comes to rest. If such a motor is now connected to the supply mains on no load, it will attain a speed practically equal to that of the primary field, the slight difference being necessary to allow sufficient cutting of flux to generate currents in the rotor of the magnitude required to overcome windage and friction. These currents will be in a direction tending to diminish the relative motion of primary field and rotor. If power is now applied to accelerate the rotor shaft, then, as it approaches synchronism, the current will diminish, until at synchronous speed the working component nearly vanishes, leaving a wattless current, and we have practically an unloaded transformer, the bigger magnetizing current being due to the air-gap and the disposition of the winding, this current being just sufficient to magnetize the core to the extent required by the back electromotive force. Now, still keeping the primary connected to the mains, increase the rotor speed, its conductors again cut the primary flux, but in an opposite direction. The currents now generated, instead of utilizing their energy in wiping out the primary magnetism, the source of the back electromotive force, are reversed and re-enforce it, thus tending to raise the stator back electromotive force above the forward, and force current back into the line. If the rotor speed is still further increased more currents are induced, the stator back electromotive force tends still further to rise, and more load will be taken; and if the capacity of this machine is sufficient and has the necessary power behind it, the load on the system will be transferred to it, and steam can be shut off the regular generator or generators supplying the system, upon which they will continue to run as motors, and supply the magnetizing current.

Now, compare some of the characteristics of this machine with that of the ordinary synchronous generator. The expression (pairs of poles by revolutions per second) will not give the correct frequency, but higher, the difference being due to the relative motion of the secondary conductors with reference to the primary field, which must occur to produce the rotor currents, or in other words, this is the negative slip; and the amount of this slip to assume a certain load will depend on the rotor resistance. The frequency will be determined solely by the currents supplied it by the synchronous machine regardless of its own speed. The speed, however, must not rise above a certain critical value, or the power required from the prime mover will fall off rapidly, due to magnetic leakage, as in the case of the motor. Provision then must be made for this in governing the engine, for should this point be exceeded the engine might run away.

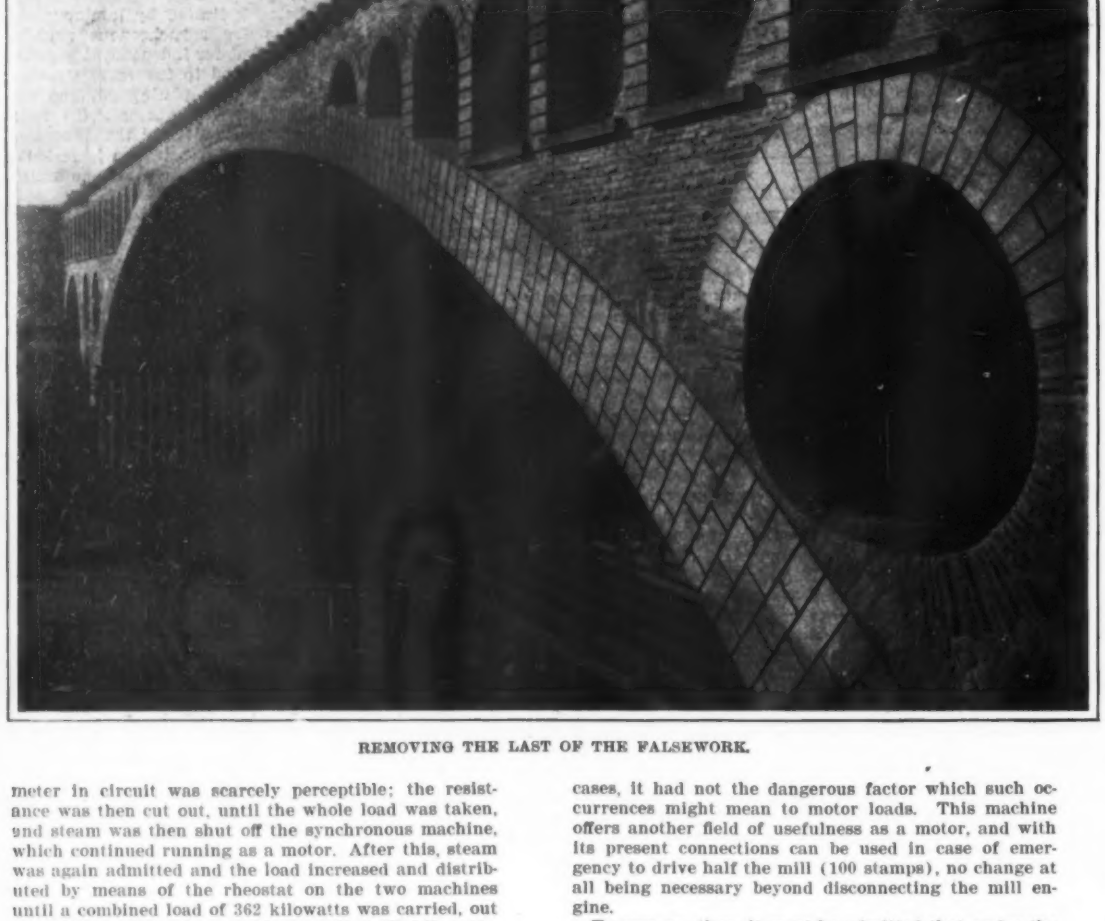
Another point, the power-factor. This will be dependent on the amount of load supplied to the system, but independent of the nature of such load, so that any currents demanded by apparatus employed on the system not in phase with the working current must be supplied by the synchronous machine. Paralleling is, of course, a simple matter, there being no need for synchronizing; it is always better, though, to get the speeds as near as possible to avoid disturbance to the system, if the machine is of large relative capacity. The possibility of running such machines for boosting purposes, as suggested by M. Le Blanc, will not be touched on here, but is mentioned as another addition to its area of usefulness.

Now, turning to another function of this machine. The synchronous part of the operation requires little or no explanation; the rotor is simply transformed into a field magnet with a continuous iron surface, instead of the usual definite polar projections. Anticipation of serious magnetic leakage in this method can be referred to results. The first trial took place under asynchronous conditions; the machine, it should be stated, has a distributing winding, three slots per phase per pole in stator and four in rotor, the number of poles being twenty-four, so that the permanent speed was 315 revolutions, or 5 per cent above synchronism at sixty cycles. At this speed or near it, and with the rotor resistance all in circuit, the switch was closed on the bus-bars, thus paralleling it with a synchronous generator which at the time was delivering ninety kilowatts. A current equivalent to 30 per cent of the non-inductive full-load current was taken, and under these conditions the disk movement of a sensitive watt-hour

* Paper read before the South African Association of Engineers.

† Induction motors are used for electric traction on mountain lines. When descending a hill electricity is forced back into the trolley wires, and a braking effect is produced, the machine acting as a generator.

‡ This method might be noted in connection with the electrical driving of stamp batteries.



REMOVING THE LAST OF THE FALSEWORK.

meter in circuit was scarcely perceptible; the resistance was then cut out, until the whole load was taken, and steam was then shut off the synchronous machine, which continued running as a motor. After this, steam was again admitted and the load increased and distributed by means of the rheostat on the two machines until a combined load of 362 kilowatts was carried, out of which the induction machine supplied 170 kilowatts. This was the limit attained and was determined by the speed of the mill engine, which was not well governed, and at this point became unstable, thus causing sudden transfers of load between the generators, and big voltage variations. A higher limit would have been obtained with a more favorable load—that is, motors of relatively small capacity or lights—but nothing less than 50-horse-power motors were available, and the switching on of such at this stage would cause a marked fall in speed of the mill engine, upon which heavy surgings of current would take place, knocking the voltage beyond control and dislocating the service.

The machine was next tried as an independent generator. More interest was attached to this test, as, if the operation proved successful, this method of working would have considerable commercial value. Two methods of exciting the rotor were available, either by cutting out one branch of the winding altogether, and connecting the other two in series to form the path for the current, or by connecting two branches in parallel and putting the combination in series with the third. This latter method was found to be more economical in exciting current. The trials under these conditions and with an induction motor load resulted in attaining an output of 180 kilowatts before the engine governing gave trouble. The excitation at this load was seven kilowatts. On a lighting load the results were extremely satisfactory, the output limit being largely increased—in fact, on certain occasions of big demand at the municipal lighting station, loads up to 315 kilowatts have been delivered with an excitation of 330 amperes at 25.5 volts. The engine under this load had got beyond governor control and fallen 4 per cent in speed, but beyond this showed no signs of distress. This load, however, was abnormal, the maximum seldom exceeding 260 kilowatts. The excitation required at no load was 138 amperes at 9.5 volts, or 1,311 watts as against 27 amperes at 133 volts (3,591 watts) for the regular generator. At loads of 180 kilowatts on similar power-factors of approximately 0.75 the excitations were 6.4 kilowatts and 5.2 kilowatts respectively; here the longer air-gap of the regular generator tells to advantage. On similar loads (lighting) of 220 kilowatts the order is reversed, the regular generator requiring 5.2 kilowatts against 4.5 kilowatts of the converted machine.

The results on the whole must be considered good. With a constant speed at the prime mover, higher limits would have been reached on motor loads; part of this was due to the governing, but large steam pressure fluctuations played no inconsiderable part, and this was in a measure unavoidable, owing to the fact that two large winding engines were supplied from the same battery of boilers. The excellent results obtainable on non-inductive loads, neglecting the part due to less armature reaction, were attributable to the gradual assumption of the load, under lighting conditions, as distinguished from the sudden changes caused by switching on motors of large relative capacity, when on inductive loads. The temporary pulling up of the prime mover under the latter conditions was, of course, noticeable on lighting loads when heavy banks of lamps were thrown on; but this occurred very seldom, and it is obvious that, although inconvenient in such cases, it had not the dangerous factor which such occurrences might mean to motor loads. This machine offers another field of usefulness as a motor, and with its present connections can be used in case of emergency to drive half the mill (100 stamps), no change at all being necessary beyond disconnecting the mill engine.

To sum up, then, it must be admitted that under the disadvantageous conditions prevailing, good results have been obtained as far as the object in view was concerned. With more power at our disposal, and under our own undivided control, still better results could have been looked for on inductive loads. Asynchronous working increased either generator capacity by about 45 per cent, and was sufficient to tide over the peak of the day load. The heavy wattless current is a serious trouble, and reduces to a great extent the advantage obtained in other directions. It could be neutralized by the use of a static condenser, but condensers of the size necessary here (capacity thirty-five microfarads) can scarcely be called commercial apparatus, and would be expensive and difficult to obtain here. Independent working was certainly a success, and up to the time of the writer leaving the company it was nearly always used as such. The short air-gap and low flux density in the rotor, although favorable as a motor, allowed a big armature reaction when generating on inductive loads, but the effects of this would not have been so noticeable with automatic voltage regulation, such as, say, the Tirrell system. As to the use of such machines in mining districts, such as the Witwatersrand, it depends entirely on circumstances. No doubt in the near future isolated electric generating plants will disappear, and be replaced by central supply stations, operating over suitable areas. When such a system is actually in sight, any immediate addition to the generating plants of mines likely to be affected by the change could be provided for by a machine such as described, which, on conversion of the systems, could at once resume its original rôle as a motor.

EXPERIMENTS WITH DYES.*

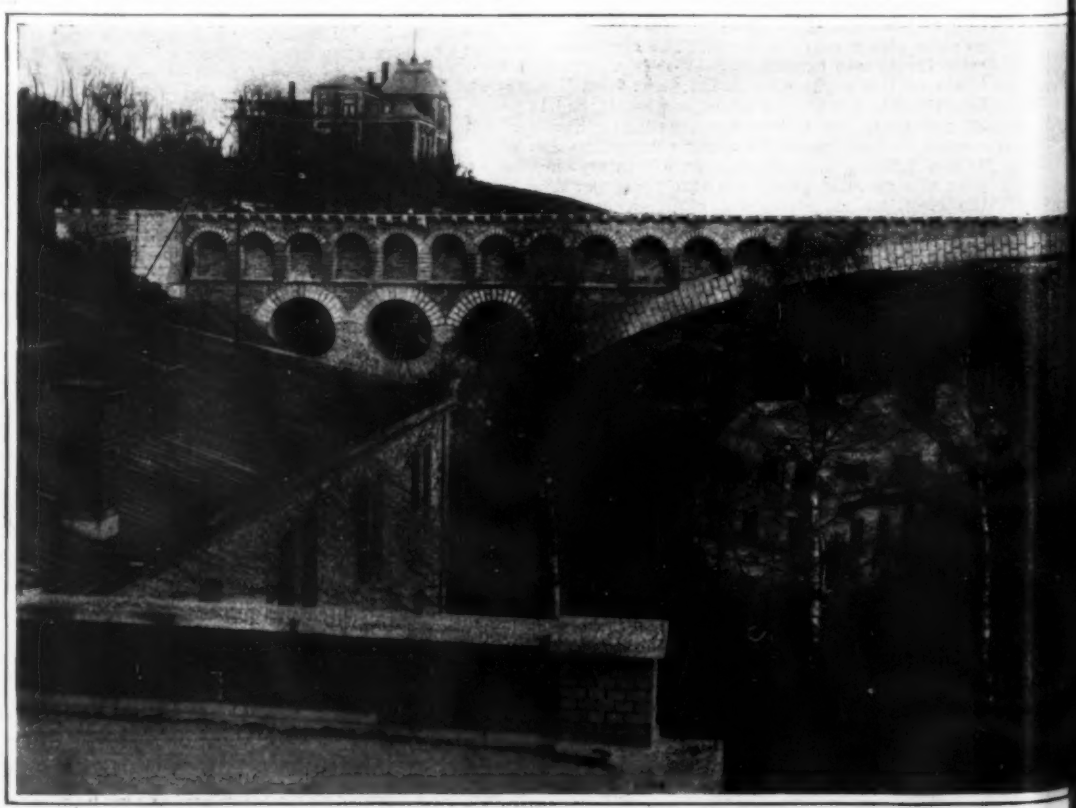
By WARREN R. SMITH, Lewis Institute, Chicago.

HAVING recently had occasion to show some simple experiments illustrating the general principles of dyeing, I was unable to find definite directions for the same and was obliged to make a number of trials before obtaining satisfactory results. I give below directions for a number of experiments which I found to work very well. It is probable that these directions could be improved, but they are fairly satisfactory in their present form and may be of advantage to some one who has not the time to work out better experiments.

In the first place, a number of points may be shown with ordinary inorganic reagents. The action of a mordant is very well illustrated by dipping a piece of cotton cloth in a solution of potassium dichromate and showing that the color is readily washed out, and then dipping a similar piece of cloth which has been soaked in lead acetate solution in the same dichromate solution. This gives yellow lead chromate, which, being insoluble, cannot be washed out of the cloth. The production of a color by oxidation may be shown by treating cotton cloth first with manganous chloride solution and then with sodium hydrate solution, rinsing, and exposing to the air. The cloth will be dyed brown by the oxidation of the manganous hydroxide. The same result may be attained more rapidly by dipping the cloth, after treating with manganous chloride, in a solution of bleaching powder which will simultaneously precipitate and oxidize the manganous compound. All the above solutions may be of the ordinary reagent strength.

With organic dyes a more varied line of experiments may be shown. The difference in the action of the dyes on animal and vegetable fibers may be shown with almost any dye, including those which, like methyl orange, are usually on hand in the laboratory for use as indicators. I have used malachite green and eosin, as they serve to illustrate another point as well. If pieces of cotton and of woolen cloth are treated with 0.5 per cent solutions of these dyes for one minute at a temperature a little below 100 deg. the wool will be found to have acquired a decided color, while the cotton has comparatively little after washing. Very likely greater differences could be obtained by using a more dilute solution for a longer time, but the rapidity of the action is an advantage for lecture table work. The same two dyes may be used to show the action of basic and acid dyes on cloth treated with basic and acid mordants. If two pieces of cotton cloth are soaked, the one in tannic acid solution, the other in sodium stannate solution and then in alum solution, it will be found that the one treated with the tannic acid will

* School Science and Mathematics.



THE PLAUEN V[illegible] COMPLETE[d]

THE LARGEST ARCH OF MASONRY IN THE WO[rld] [is] F[eet]

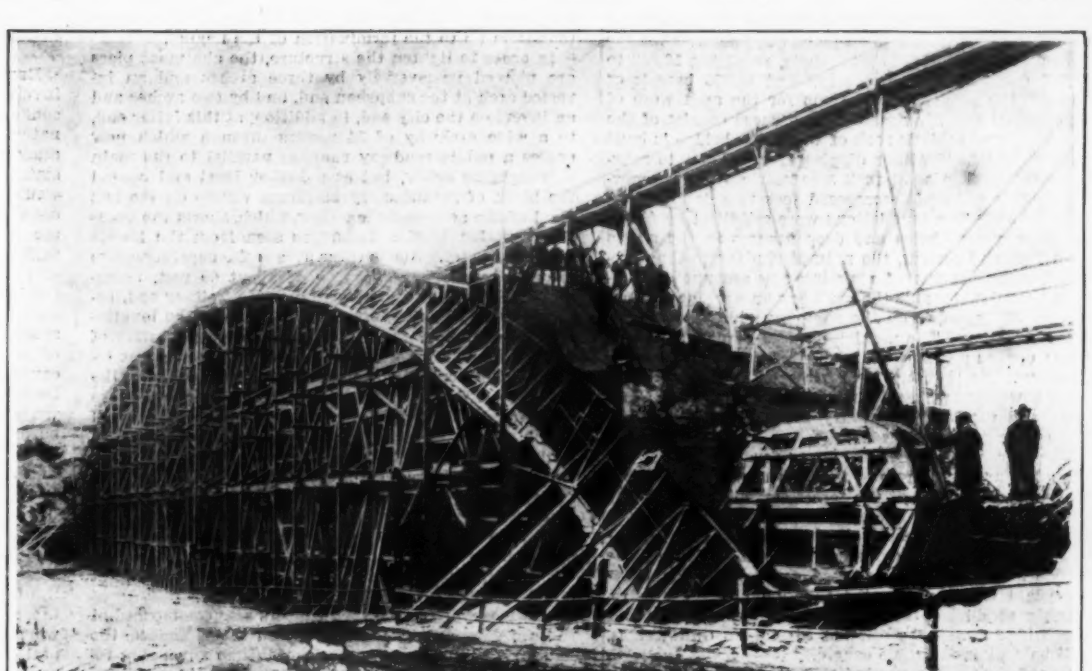
e dyed by the basic malachite green and unaffected by the acid eosin, while the reverse will be true of that treated with the basic mordant.

Reduction to the colorless leuco dye and subsequent oxidation is well shown with indigo. If 2 grammes of indigo powder, 5 grammes of zinc dust, and 10 grammes of slaked lime are mixed with 200 cubic centimeters of water in a stoppered bottle, in a short time the indigo will go into solution as the colorless indigo white. If a piece of cloth is dipped in this solution and then rinsed and exposed to the air it will soon acquire a fine blue color.

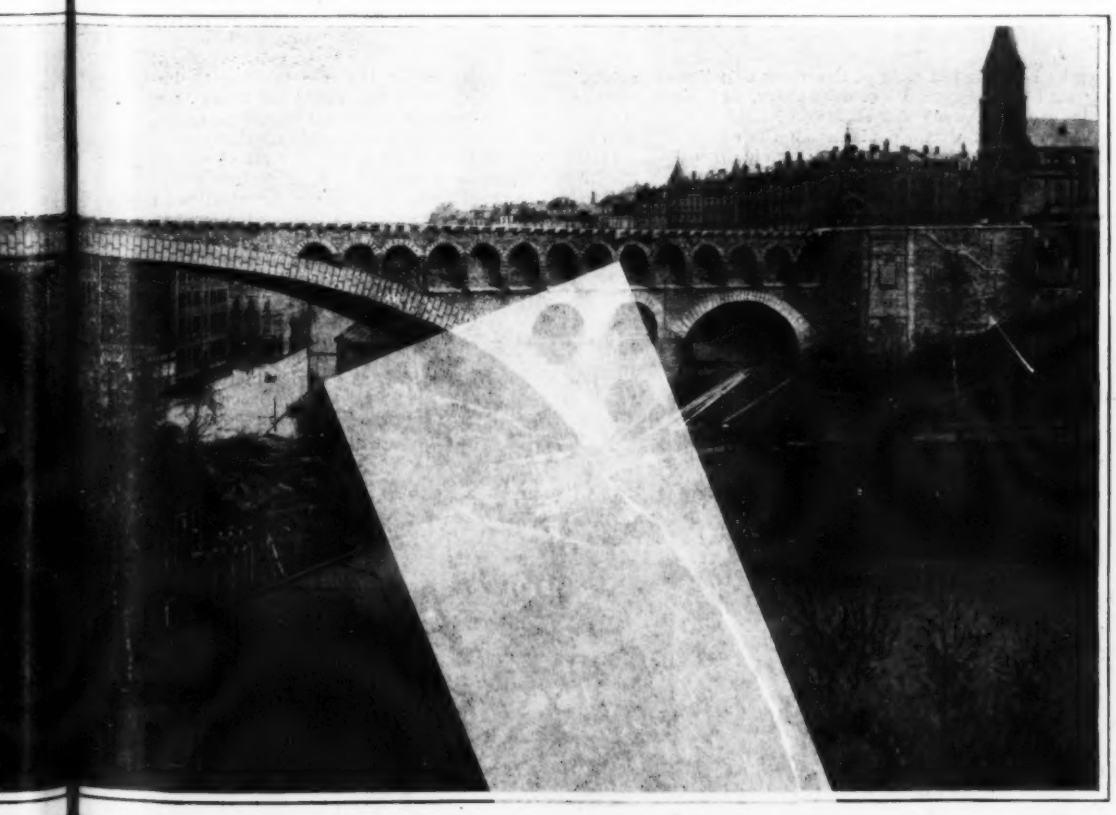
The action of a polygenetic dye may be shown on the mordanted cloth, which can be obtained from any dealer in chemical supplies. This acquires several different shades if boiled for some time in water to which a small amount of alizarin has been added. The action is more rapid if a quantity of ammonia insufficient to dissolve all the alizarin is added to the water. Other experiments which may be shown if the dyes are available are the formation of alizarin blue on heating and the action of any of the direct cotton dyes.

THE ORIGIN OF LITHOGRAPHY.

LITHOGRAPHY, in common with many of the most important inventions in every branch of the arts, owes its origin to an accident arising from the necessitous circumstances of the inventor. Aloys Senefelder, an actor at one of the theaters at Munich, was the individual who was thus enabled to immortalize his name as the inventor of an art. Senefelder's histrionic pursuits do not appear to have been a source of any material profit to him, for he describes himself as being in a state of great pecuniary distress. In the year 1792 he added the title of author to that of actor, by publishing a tragedy which, from the delay in getting it printed in time for the Leipsic fair, produced little or nothing more than the expenses. This circumstance induced the desire to be the printer of his own productions; but his means being too limited to admit of his purchasing a press and other necessary materials, he had recourse to a variety of expedients to supply the deficiency; and among others, that of etching his writings on copper plates. While so engaged, he was induced to make several experiments in the composition of ink or other writing materials best adapted for correcting any mistakes he might make in his writing on the copper, the result of which was the adoption of a composition of wax, soap, and lampblack. This appeared for some time to promise success; but the expense of the copper plates was a serious objection to Senefelder, who was as yet only practising the art of writing in inverted characters on copper, preparatory to the application of his plan to the publication of his works. It occurred to him that he might perhaps be able to use a flat piece of Kellheim stone, which he had procured for the purpose of grinding his colors, with as good effect for this practice as the copper; and having discovered a method of cleaning off the writing from the stone when done with, he availed himself of the stone as a substitute for copper plates, without, however, contemplating the possibility of taking impressions from it, or of its application to any other purpose than that of a substitute for copper on which to practise inverted writing. It chanced, however, that he was one day applied to by his mother to make out a list of clothes for the laundress; neither ink nor paper was at hand, but the piece of stone had just been polished from the last writing, and had not been covered with the varnish preparatory to a new one, and in the hurry of the moment he dipped a pen into his composition ink and wrote the required list on the stone, intending to copy it off at his leisure. When, however, he prepared to do so some hours afterward the writing appeared so firm and good on the stone that it occurred to him to try what effect would be produced by biting-in the stone with aquafortis and taking an impression from it. He did so, and found to his surprise and joy that at the expiration of five minutes the stone was eaten in to the depth of a one-hundred-and-twentieth part of an inch, and the writing consequently elevated in an equal degree. He then applied his composition printing ink to the writing, and with much less force than was requisite to take off an impression from the copper obtained a perfect reversed impression of his writing. Thus he perceived that this Kellheim stone possessed an inherent property of imbibing and retaining grease so as to admit of an impression being taken of anything written with such materials after the writing had been rendered prominent by the other parts of the stone being eaten away with aquafortis. From the discovery of this property proceeded the invention of lithography. The first efforts of Senefelder to improve upon his new discovery were as laborious as they were inefficient, but by dint of that ardent and unconquerable perseverance which was the leading characteristic of his mind he at length attained his long-sought object, that of tracing characters in his composition ink upon the stone and taking perfect impressions of them.—Architect and Contract Reporter.



ARCHING COMPLETED AND SUPERSTRUCTURE ON HAUNCHES COMMENCED IN THE SPRING OF 1904.



OMPLETED.

THE WO[illegible] FEET, 3 INCHES BETWEEN ABUTMENTS.

THE PLAUEN VIADUCT.

By Our English Correspondent.

THE Plauen viaduct, known locally as the Syrathal viaduct, because it bridges the Thal, or valley of the Syra, was finally completed during the early part of this year. It comprises the largest arch masonry ring in the world, that is, 295 feet 3 inches between the abutments.

It is a monolithic structure in so far as the bridge masonry forms a rigid mass, entirely without hinges. The use of hinges in a span of such length would have seriously increased the expense of the structure, and the benefit to be derived from such a complication in the work was far from being guaranteed. The process of construction commonly adopted for large spans, and followed in this case, insured a certain elasticity—that is, by loading the arch centering or falsework with the total weight to be supported previous to building the ring from that point in the haunches considered as the real imposts of the arch and where the length of span is only 65 meters (213 feet 3 inches).

The arch forms a composite curve, being struck from five centers, the crown having a radius of 105 meters, the springings 58.5 meters, and the haunches, which are balanced, or cantilever, masses, 30.1 meters radius.

In the work of calculation the bridge was considered as divided into three parts, that arc between the imposts on springing in the 65-meter span being taken to represent the arch proper with *encastré* footings, while the remaining portions of 12.5 meters on either side ($65 + 12.5 + 12.5 = 90$) were counted as rigid abutments.

Considered thus, the flatness of the central span becomes exceptional, and equal to ten times the rise. For the whole visible span of 90 meters this proportion descends by half, being then only 5 to 1; the span to be calculated remains, however, with a flatness of arc averaging 10 to 1.

In the preliminary graphic calculations made to determine the static forces in the various divisions of the arch, the maximum compressions due to dead and live loads combined were computed as 32.4 kilogrammes per square centimeter at the crown, 26.9 kilogrammes per square centimeter in the springings, 53.4 kilogrammes per square centimeter in the abutments, and 23.9 kilogrammes under the arch footings.

The foundations of the arch ring have a width of 8 feet 2 inches by a length (through the arch) of 52 feet 6 inches. The weight in the foundations is approximately 15,000 tons and equals a pressure of 330 pounds on each square inch of foundation.

The stones used for the arch ring voussoirs throughout and also for the walls are parallel slabs of schistic rock ranging in thickness from 3½ to 4¾ inches and of a maximum length of 40 inches in the great arch ring. It is known as "Theumder frucht-schiefer," or phyllite schist, a hard stone of olive-green hue, having when dry a specific gravity of 2.8 and a crushing resistance of 1,880 kilogrammes per square centimeter (= 11.3 tons per square inch).

The cement mortar employed in the arch had a crushing resistance at 28 days of 240 kilogrammes per square centimeter, at 13 weeks of 320 kilogrammes, and at 26 weeks of 370 kilogrammes per square centimeter. Its tensile strengths at the ages mentioned were respectively 12, 15, and 18 kilogrammes per square centimeter. In tests upon air-dried specimen cubes its resistance to crushing in 45 days was 400 kilogrammes per square centimeter with a tensile strength of 40

kilogrammes; at 24 weeks the crushing resistance was over 600 kilogrammes per square centimeter.

In a structure of this magnitude, requiring 10,000 to 12,000 cubic meters of masonry and 12,000 barrels of cement, the natural foundations for the arch were of first importance for its stability. These consist of the same order of schistic rock of which the bridge is built with their stratifications dipping from 45 deg. to nearly vertical. The solid rock was reached after removing surface soil and decomposed rock to a depth of 1½ to 2 meters. The foundations were solidified by filling up some quarry holes and deep fissures in the seams with Portland cement, the natural abutments thus prepared being capable of resisting any amount of pressure. On the city side the bank has an average inclination of 30 deg., and on the suburban side of 45 deg.

Construction.—The municipality of Plauen (in Vogtland) opened a competition both for steel and masonry structure, the lowest price for a metallic bridge being from a well-known engineering firm of Zwickau (Saxony) and that for a masonry bridge from Liebold & Co., of Langebrück-Dresden.

The first work undertaken was for the building of the great arch centers and falseworks which were provisionally assembled at the forest sawmill yards of the contracting firm at Klotzsche near Dresden. In the support of the falseworks sixteen trenches (see Fig. 6) were excavated transversely to the direction of the bridge and filled with rammed concrete. Upon these were laid planks of fir, the function of which, in replacing sand-boxes at the stage of operations when the bridge was to be allowed to feel its own weight, will be explained in due course.

The falseworks were built in three stages or platforms, the trusses of the ground and intermediary stages being eleven in number, and those next the intrados twenty-one in number. The alignment of the arch centering, properly so called, was effected by wedges on the third staging.

The final work was to lag the surface of the timber arch, these pine boards being cramped up to tight joints, and the latter dressed so that the cement facing of the soffit would be left dead smooth when they were removed.

On each side of this boarded surface vertical moldboards were erected, these latter being planted inside with fillets, which would give the appearance of cut-stone joints to the cement facing over the arch ring when the boards were removed. These boards are conspicuous in all the subjoined views of the finished arch.

Work on building the arch ring then commenced (August 21, 1903), the voussoirs being laid in the wet cement facing of the intrados, and the edge stones were set into the vertical cement facing of the arch ring. There are in the arch two courses of voussoirs alternating with a third course for the break joints.

In order to construct the arch as nearly as possible in accordance with the theoretical hypotheses of the elastic arch, and to obviate secondary stresses and their reactions, it was built in nine different sections, the lowest of which commences a little below the span of 65 meters, and which we have termed the imposts of the arch. The load of stones having been piled on the arch centering, the building of these arch sections commenced, leaving, finally, only the wedge-shaped intervals in the extrados shown in the section (Fig. 6). These openings, 1 meter long at the bottom and 2 meters long at the top, were timbered with struts adjustable in length by screw-worked wedges, thus maintaining the intervals open with a certain measure of flexibility serving to compensate the inevitable movements of the falseworks during the progress of the construction. The work was completed by removing the wooden keys at each extremity of the crown section and proceeding downward on each side to terminate the masonry keying at the haunches. A total deflection of 2½ centimeters (1 inch) occurred in the middle of the centerings after the falsework had been fully loaded, but no perceptible change occurred from that time up to the termination of the keying.

In order to lighten the structure, the abutment piers are pierced transversely by three arches and an inverted arch at the suburban end, and by two arches and an invert on the city end, in addition, at this latter end, to a wide archway of 14 meters through which now passes a public roadway running parallel to the main thoroughfare below, but at a higher level and behind the block of manufactory buildings visible on the left hand of the accompanying view, which shows the peculiar situation of the viaduct as seen from the lowest part of the city. Above these arches the superstructure is entirely cellular—a length of about 60 feet, terminating above the imposts of the arch at either end, being traversed by five internal pier walls in the longitudinal direction of the bridge, and forming a series of six arches. This work is all ashlar without cement facings. The pier walls are 40 centimeters thick, and the archways 1.5 meters in width. The outer walls are of coursed masonry throughout, except for the small angular surfaces below the small arches, which are of ashlar masonry.

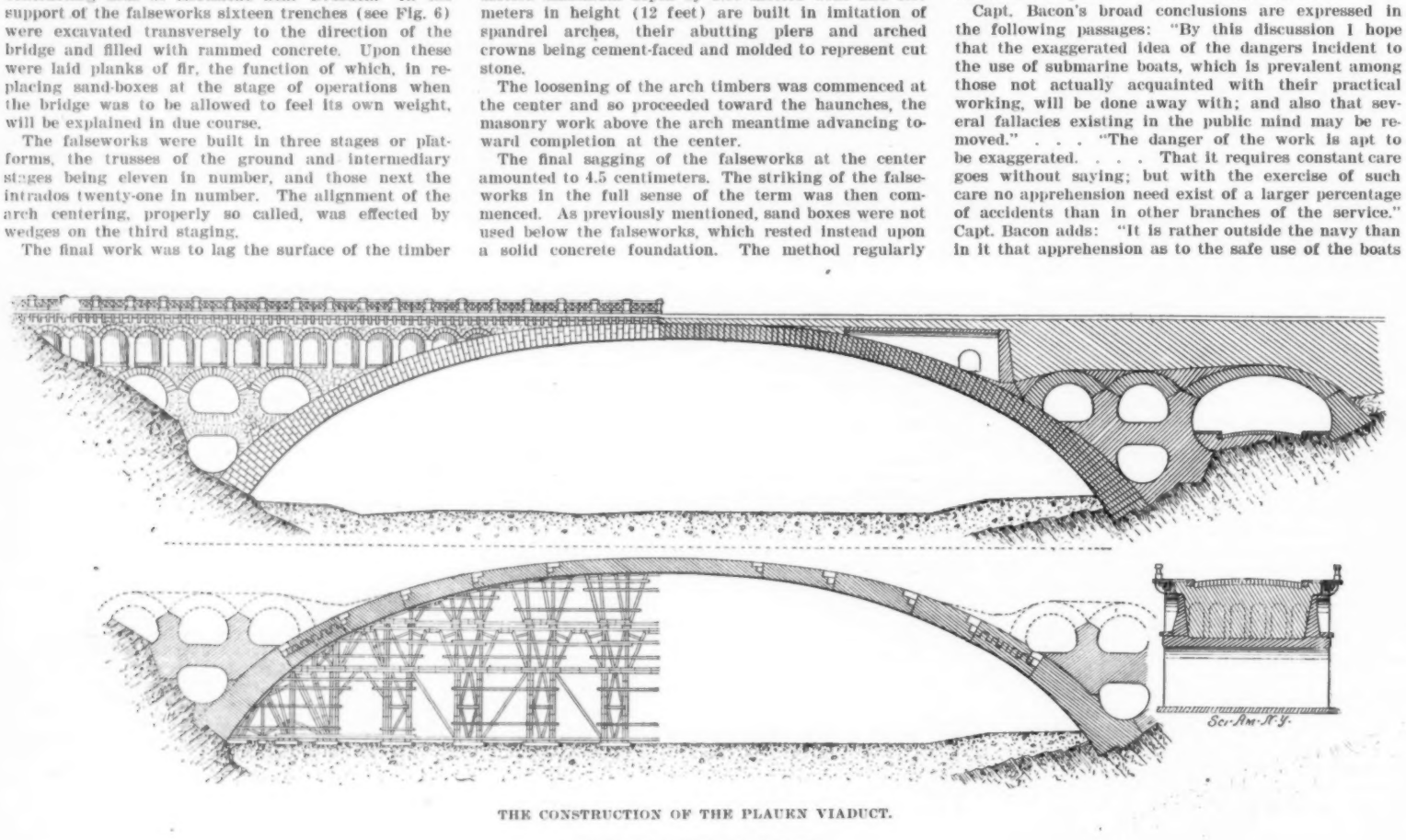
For the purpose of relieving the effect of a solid outside wall of masonry, a series of niches of 1.20 meters maximum depth by 2.50 meters wide and 3.60 meters in height (12 feet) are built in imitation of spandrel arches, their abutting piers and arched crowns being cement-faced and molded to represent cut stone.

The loosening of the arch timbers was commenced at the center and so proceeded toward the haunches, the masonry work above the arch meantime advancing toward completion at the center.

The final sagging of the falseworks at the center amounted to 4.5 centimeters. The striking of the falseworks in the full sense of the term was then commenced. As previously mentioned, sand boxes were not used below the falseworks, which rested instead upon a solid concrete foundation. The method regularly practised by Liebolds has none of the many objections existing with the employment of sand boxes, as it depends, in principle, upon the sinking of hard wood into a soft wood. Soft wood planks on the concrete sills, about 7 centimeters thick, are overlaid by oak planks upon which the false work posts are stepped. The oak planks are first sawn through square down to the soft wood bearers, so that with this reduced bearing surface below the posts, they crush down into the yielding wood. The bearing surface is then reduced again and again according to needs until, in some cases where the arch deflection is necessarily greatest, the posts finally rest upon the points of hardwood wedges sunk into soft timber. This device in the case of the Plauen viaduct worked well, and probably contributed in an appreciable measure to the success of the operations and of the final work.

The deflection of the arch at the center when freed from all support amounted to 36 millimeters. This refers, of course, to the actual settling due to the compression of the masonry as distinct from the 4½ centimeters sagging of the falseworks which, in this special system of arch construction described, can scarcely be added except perhaps to show that out of the 15 centimeters original superelevation of the falseworks, at the center, 9.1 centimeters was the subsequent total amount of lowering at the soffit.

The bridge was designed and its construction superintended by Mr. C. Liebold. It was proposed to open the bridge to the public during the present summer. For facilities in inspecting the bridge works acknowledgments are due to the courtesy of the contracting engineers.



THE CONSTRUCTION OF THE PLAUEN VIADUCT.

THE PLAUEN VIADUCT.

Ink for Writing on Celluloid.—Take 100 parts of acetone, and in one portion only of this dangerous liquid, dissolve 10 parts of chloride of iron, while, in the remainder, dissolve 15 parts of tannin and mingle.—La Nature.

SUBMARINES.—IV.*

By SIR WILLIAM H. WHITE, K.C.B.

RECENT accidents to British and French submarines, involving serious loss of life, have disturbed public confidence in the safety of vessels of the type. It was natural, therefore, that the Admiralty should desire to allay anxiety, and to put forward an authoritative statement on the subject, by means of which replies would be made to criticisms and suggestions that had appeared in the press. Capt. Bacon's paper read before the Institution of Naval Architects on July 20 admirably fulfilled this purpose. In form it was an expression of individual opinion by an officer who possessed exceptional experience in submarine navigation; in substance it was an exposition of Admiralty views respecting accidents that have occurred, the relative risks of submarines and other vessels, the most probable cause of accident, and the precautions that should be taken to prevent accidents. Limits of time prevented adequate discussion of this important contribution by members of the technical society to which it was presented; and the writer therefore proposes to briefly review the main points raised by Capt. Bacon, although some of them have been mentioned or illustrated in previous articles of this series.

Capt. Bacon's broad conclusions are expressed in the following passages: "By this discussion I hope that the exaggerated idea of the dangers incident to the use of submarine boats, which is prevalent among those not actually acquainted with their practical working, will be done away with; and also that several fallacies existing in the public mind may be removed." . . . "The danger of the work is apt to be exaggerated. . . . That it requires constant care goes without saying; but with the exercise of such care no apprehension need exist of a larger percentage of accidents than in other branches of the service." Capt. Bacon adds: "It is rather outside the navy than in it that apprehension as to the safe use of the boats arises." This statement of the case is of great importance, because Capt. Bacon would not have read the paper without the sanction of his official superiors, who may be considered to approve his conclusions.

In the public interest, and in the interest of officers and men serving in submarines, it is desirable that there shall be neither exaggeration nor depreciation in estimates of the possible dangers attending the employment of submarine vessels. While heartily sympathizing with the intention underlying Capt. Bacon's paper, and recognizing the importance of avoiding unreasonable action tending to disturb the confidence of crews of submarines, one may be permitted to doubt whether familiarity with risks attaching to this type of vessel, and the comparative infrequency of accidents during the experimental period of their service in the royal navy, have not tended to make Capt. Bacon underestimate dangers which are inherent in submarine navigation after all possible precautions have been taken. It is proposed, therefore, to endeavor to indicate the exact position of this matter so far as experience permits; but it will be clearly understood that in doing so there is no suggestion on the part of the writer that the Admiralty and those working for them have not done all in their power to provide against dangers which could be foreseen, or that they have failed to take every known precaution to secure safety.

In dealing with submarines, one has to face the unknown in many respects. Their singular form, their small reserve of buoyancy, their exceptional conditions of stability, and their capacity for total submergence all tend to differentiate them from other types of vessels, and to introduce new and difficult conditions. Assuming that everything has been done by the naval architect in the form of calculation and model experiment, it still remains true that actual ex-

* London Times. Sir William White's previous articles have appeared in SCIENTIFIC AMERICAN SUPPLEMENTS Nos. 1536, 1537, and 1538.

perience in service with full-sized vessels may, and probably will, lead to fresh discoveries; and one purpose of this paper is to indicate details for which, after thorough investigation, the writer considers further information is required if accidents are to be minimized. Although the writer is not in possession of drawings giving the exact forms of submarines recently added to the royal navy, he has corresponding information for other submarines; and from published dimensions and particulars for our own vessels a naval architect can approximate closely to their forms. This has been done and detailed calculations have been made for the variations in buoyancy and stability accompanying each stage of immersion from the "awash" to the diving and submerged conditions. On these investigations the general conclusions stated in previous articles are based, and they have brought to light certain facts which have not been generally recognized or fully appreciated hitherto. It seems preferable, however, for present purposes, to adopt figures given in evidence before the court martial on the foundering of "A8" by official witnesses, who used the results of calculations made by Admiralty constructors, which results agree, so far as they go, with calculations made by the writer.

A few preliminary explanations may be of service. It is generally known that submarines are almost without exception "cigar" shaped; their cross-sections are usually circular, and the top and bottom outlines of the profile (or side view) approximate to flattened circular segments of large radius. This form is primarily adopted in order to obtain with a minimum of material and weight, the great structural strength required to resist severe external pressure experienced at considerable depths below the surface. Upon the upper portions of submarines light superstructures are often built; and the outer form of the hull proper is thus somewhat disguised. A conning tower of truncated conical form is also constructed near the middle of the length, above the upper portion of the vessel. Entrance into the interior is obtained by means of a hatchway, fitted with a hinged water-tight cover, forming the top of the conning tower. The height of the tower has been increased considerably in recent vessels. When a submarine is in her "surface" condition with water-ballast tanks empty, the upper portions of the hull proper project only to a small height above water; and the reserve of buoyancy (measured by the volume of the water-excluding portions of the hull situated above the level of the water surface) is of very moderate amount. In the case of "A8" Capt. Bacon stated to the court martial that this maximum reserve of buoyancy was about 13 tons, exclusive of the volume of the conning tower, which was 1¾ tons. Another witness, representing the builders, stated that the reserve of buoyancy in this condition was 16 tons, including the conning tower. It is deducible from statements made at the court martial that the corresponding displacement of "A8" was approximately 200 tons; so that (including the conning tower) the reserve of buoyancy was about 8 per cent of the displacement. The smallness of this percentage will be better understood by comparison with the corresponding figures for other types of ships. In low-freeboard American monitors—which were employed during the civil war and had their upper decks from one to two feet above water—the corresponding reserve of buoyancy was about 10 per cent of the displacement at load draft. Several of these vessels foundered off the Confederate coast in consequence of the entry of water through hatchways that had been left open for access of ventilation. Breastwork monitors of the royal navy, which were low-freeboard vessels, had a reserve of buoyancy of 30 per cent of the displacement. In high-sided warships and passenger steamers, the reserve of buoyancy frequently rises to 80 or even 100 per cent of the displacement. In cargo-carrying merchant vessels when fully laden, the reserve of buoyancy at load draft varies from about 25 to 40 per cent of the displacement. It will be seen, therefore, that submarines such as "A8" have at their lightest draft a reserve of buoyancy very much smaller than that of other types at their deep-load draft, and are consequently exposed to special risks of foundering.

At the time of the accident, "A8" was considerably worse off than this. It is established by the evidence that the reserve of buoyancy was then about six tons, excluding the conning tower, and about eight tons including the tower, or only 4 per cent of the corresponding displacement. In this condition she was run at a speed of about ten knots with the hatchway open, as it had to be when the gasoline engine was at work. It is proper to note that the sea was calm, and that the hatchway was at the top of the conning tower, about 10 feet above water. Further, all the expert witnesses agreed that their previous experience led them to anticipate no danger of foundering in the condition described. But as a matter of fact, certified by the commanding officer, Lieut. Candy—although he took the precaution to trim the boat 4 deg. by the stern, instead of 2 deg. to 2½ deg. which was the usual surface trim, so as to lessen the danger of the bow plunging below the surface—less than 15 seconds elapsed between the moment when the top of the low superstructure forward was at the water-level, and the moment when the water came close up to the tops of the conning tower in consequence of the bow dipping deeply below the surface. Lieut. Candy then decided to stop the engine, but was washed overboard before his intention could be carried out. The water rushed through the open hatchway, and it is estimated that 20 to 30 tons entered the interior before the cover was closed by the inrush. This water ran forward, the bow became still more depressed, and the unfortunate vessel dived to the bottom, where she remained with her bow buried in the mud at a considerable inclination to the horizontal, all on board perishing.

Apart from the evidence of credible witnesses it is obvious that those in charge would not have run "A8" at this speed with so small a reserve of buoyancy, had they considered danger to be possible. From a careful analysis of the evidence—and especially that of Lieut. Candy—it appears that "A8" had never previously been run at the surface with so small a reserve of buoyancy, and that her deeper draft was due to the retention in the tanks of a considerable weight of water-ballast which might have been expelled. Lieut. Candy stated that No. 2 ballast tank was nearly full (about 4½ tons), about half a ton of water might have been in the trimming tank forward, and about one ton in the after trimming tank, making a total of six tons water-ballast, and lessening the reserve of buoyancy by that amount. Capt. Bacon stated that in a sister vessel, when No. 2 tank was filled, the reserve of buoyancy was found to be nine tons, and, as the court martial compared this with six tons reserve of buoyancy for "A8," it appears that the conning tower was excluded. But Capt. Bacon added that, in order to get this sister vessel to the trim reported for "A8" (4 deg. by the stern) immediately before the accident, he found it necessary to introduce about three tons of water into the after auxiliary tank; and he therefore concluded—as was perfectly reasonable—that "this three tons must have been in one of the tanks of 'A8' somewhere in the after part," although Lieut. Candy was unaware of the fact. That officer stated in evidence that water put into the auxiliary tanks cannot be measured, and he may have under-estimated the amount used to secure the exceptional trim of 4 deg. by the stern. From this *résumé* of the evidence it will be seen that the condition of "A8" just before she proceeded at 10 knots speed seems to have been clearly established by the inquiry; that she was exceptionally deep, and at an unusual trim, so that her condition was outside previous experience, although no one concerned anticipated danger. Although there were eight men on board additional to the regular crew, the petrol tanks were not full, and the corresponding reduction in weight of petrol exceeded the extra weight of crew by fully a ton. The essential facts to be noted, therefore, are that the reserve of buoyancy was only one-half that which was possible with no water-ballast on board; that this deeper draft produced a very serious diminution in longitudinal stability and in the power to resist changes of trim produced by external fluid pressure or transfer of weights inboard; and that as a consequence the risk of sudden diving at the bow was greatly increased as compared with the condition of the vessel when her *maximum* reserve of buoyancy was secured by emptying the ballast tanks.

DENATURIZED ALCOHOL.

TECHNICAL PURPOSES FOR WHICH EMPLOYED.

CONSUL-GENERAL MASON, of Berlin, complying with special instructions, furnishes an interesting report concerning the manufacture and use of alcohol for fuel and other industrial purposes in Germany. Consul-General Mason made a report on this subject in June last, which was printed in Daily Consular and Trade Reports of July 24, and in which were included some of the facts stated in the present report. The consul writes:

The official statistics of last year's campaign, viz., from September 1, 1903, to August 31, 1904, give the following as the total output of alcohol from each of the three principal raw materials during the year:

	Hectoliters.
From potatoes	3,045,605
From grains	692,483
From beet molasses	116,211
Total	3,854,299

Equal to 101,823,470 gallons.

The spirits distilled from grain and molasses and the small quantities made from cherries, grape-must, plums, etc., are used mainly for drinking and the manufacture of medicines, perfumes, vinegar, and various other food preparations. The great source of industrial alcohol is from potatoes, and it is used for heating, lighting, and motor purposes, and for a vast number of applications in chemical and industrial manufactures. For the reasons explained in my previous report, the consumption of alcohol in Germany as fuel for portable and stationary engines, automobiles, etc., has decreased rather than increased the past two years, and amounted during the last campaign year to not more than 951,000 gallons, or less than 1 per cent of the whole alcohol product of the same year.

For most industrial purposes alcohol is used in Germany duty free, after having been "denaturized," or rendered unfit for drinking purposes, by admixture, in presence of a government official, with a prescribed percentage or proportion of one or more of several different substances prescribed in the very elaborate statute which governs that complicated subject in this country. There are two general classes or degrees of denaturizing, viz., the "complete" and the "incomplete," according to the purpose for which the alcohol so denaturized is to be ultimately used.

GERMAN METHODS OF DENATURIZING.

I. Complete denaturization by the German system is accomplished by the addition to every 100 liters (equal to 26½ gallons) of spirits:

(*a*) Two and one-half liters of the "standard denaturizer," made of 4 parts of wood alcohol, 1 part of pyridin (a nitrogenous base obtained by distilling bone oil or coal tar), with the addition of 50 grammes to each liter of oil of lavender or rosemary.

(*b*) One and one-fourth liters of the above "standard" and 2 liters of benzol with every 100 liters of alcohol.

Of alcohol thus completely denaturized there was used in Germany, during the campaign year 1903-4, 931,406 hectoliters denaturized by process (*a*), as described above, and 52,764 hectoliters which had been denaturized by process (*b*). This made a total of 26,080,505 gallons of wholly denaturized spirits used during the year for heating, lighting, and various processes of manufacture.

II. Incomplete denaturization—i. e., sufficient to prevent alcohol from being drunk, but not to disqualify it from use for various special purposes, for which the wholly denaturized spirits would be unavailable—is accomplished by several methods as follows, the quantity and nature of each substance given being the prescribed dose for each 100 liters (26½ gallons) of spirits:

(*c*) Five liters of wood alcohol or one-half liter of pyridin.

(*d*) Twenty liters of solution of shellac, containing 1 part gum to 2 parts alcohol of 90 per cent purity. Alcohol for the manufacture of celluloid and pegamoid is denaturized.

(*e*) By the addition of 1 kilogramme of camphor or 2 liters of oil of turpentine or one-half liter benzol to each 100 liters of spirits. Alcohol to be used in the manufacture of ethers, aldehyde, agarcin, white lead, bromo-silver gelatins, photographic papers and plates, electrode plates, collodion, salicylic acid and salts, aniline chemistry, and a great number of other purposes, is denaturized by the addition of—

(*f*) Ten liters sulphuric ether, or 1 liter of benzol, or one-half liter oil of turpentine, or 0.025 liter of animal oil.

For the manufacture of varnishes and inks alcohol is denaturized by the addition of oil of turpentine or animal oil, and for the production of soda soaps by the addition of 1 kilogramme of castor oil. Alcohol for the production of lanolin is prepared by adding 5 liters of benzine to each hectoliter of spirits.

The whole amount of incompletely denaturized alcohol of the several grades above described which was consumed in Germany last year was 385,946 hectoliters, equal to 10,227,569 gallons. In addition to all the foregoing, 21,779 hectoliters of alcohol were used duty free and without denaturization of any kind for governmental or public purposes, such as hospitals, government laboratories, and for the manufacture of fulminates and smokeless powder.

COST OF PRODUCTION.

The cost of manufacture of alcohol in Germany varies in the different states and provinces of the empire, and still more from year to year, in accordance with the yield and consequent market price of potatoes, grains, and other materials. In Prussia during the past year the wholesale price of fully denaturized spirits of 90 to 95 per cent strength has ranged from 35 to 50 pfennigs per liter, which would be from $8.56 to $11.90 per hectoliter of 26½ gallons—say 32.3 to 45 cents per gallon. This was a marked advance over the prices of the campaign years 1901-2 and 1902-3, when, by reason of the enormous potato crop and consequent overproduction of spirits in 1901, the open market rate for denaturized alcohol of the grade used for motor purposes declined to 15 and 17 cents per gallon, but has now risen to from 31½ to 35 cents per gallon for the same quality. It goes without saying that much of the alcohol sold for the prices of 1901, 1902, and 1903 brought to the producer the bare cost of manufacture, or even less, whereas the industry is now, generally speaking, profitable and prosperous. Alcohol as a fuel for motors requires for the best results an admixture of from 15 to 30 per cent of benzol, and at the present cost of denaturized spirits is no longer an economical motor fuel in Germany.

WANDERING TEACHERS IN BAVARIA.

CONSUL BARDEL, writing from Bamberg, Germany, says that in order to promote agricultural interests the Kingdom of Bavaria has established agricultural schools in thirty-one towns. These schools are in charge of teachers who, in addition to an academical education, must be generally efficient in botany, geology, chemistry, physics, zoology, and natural history. The consul says:

At a time when nothing is doing in the fields, from November to March, these schools are open, and peasant farmers for a nominal fee can attend courses on cultivation and fertilization of the soil, the proper succession of crops on the same land, the best sources for good seeds, irrigation, and the raising of stock. They are made acquainted with improvements and new inventions in agricultural implements the adoption of which can be recommended. They are taught the rudiments of bookkeeping and other commercial knowledge essential for the up-to-date farmer.

In the spring, after these farmers have returned to their work in the fields, it becomes the duty of the teachers who instructed them during the winter to travel from county to county and to act as advisors to the farmers. Much good results from the travels of these wandering teachers. By practical suggestions to the farmers they induce them to make valuable improvements in the cultivation of their farms.

The wandering teacher helps to form co-operative clubs for the joint interests of a number of farmers in

one district. From time to time the teacher has to lecture in these clubs on any subject practical or scientific which might prove of interest to the members. These visits and lectures to the different districts are entirely free to the people, since the state assumes all expenses. There is probably no other country in the world in which so much is done by the state for its rural inhabitants as is the case in Bavaria. Other German states have these agricultural schools, but their teachers are not sent in such a practical way direct to the places where they can do the most good, as is done here. The results of this commendable care have been very gratifying.

SAKHALIN—WHAT IT IS.

In a book published in 1903 under the title of "Un Bagne Russe. L'Ile de Sakhaline," M. Paul Labbé gives an interesting account of the aboriginal tribes and Russian convicts on the island of Sakhalin.

It is unnecessary to allude to the physical characteristics of Sakhalin. They have been sufficiently described since the island has occupied so large a space in the eyes of the world. Of the value of Sakhalin to the Russians, apart from strategical or political reasons, M. Labbé has this to say: "Sakhalin is only a speck in the vast Asiatic possessions of Russia, where there are so many richer provinces more accessible and less difficult to colonize. Russia has much to initiate and accomplish in its Asiatic empire. It will gain nothing by diffusing its efforts. Sakhalin is maintained at great cost; which will become more onerous in the future. . . . Russians never speak of Sakhalin except in terms of vague horror."

Of the Russian officials stationed on the island, the author says that they have two great defects—love of liquor and of cards. Their gambling debts assume large proportions. German and Russian commercial houses at Vladivostock lend willingly to these gentry, taking advantage of their indebtedness, which can never be liquidated, to wring valuable concessions from them. Although M. Labbé does not say it in so many words, he leaves it to be inferred that the administration of the island is utterly rotten and corrupt.

There are two tribes of aborigines, restricted in numbers, living on Sakhalin. The Guiliaks, who occupy the northern, and the Aïnos, to whom is reserved the southern end. The Guiliaks are supposed to have migrated from the valley of the Amur; but their habitations, tools and customs suggest the extreme northern portion of the American continent as their place of origin. The Guiliaks, being brought more in contact with Russian convicts than the Aïnos, are very much more deteriorated and corrupt than the latter, who are more in touch with the Japanese. The Guiliaks always speak with terror of their first acquaintance with the Russians. They regard them as savages and monsters.

A Guiliak village rarely consists of more than six houses. When a white man approaches one of them he is greeted with the furious barking of dogs. If they happen not to be tethered or under control of a native he will surely be attacked and devoured. These animals are always rendered furious by the scent of a white man, whose odor they have never been able to endure. The wealth of a Guiliak consists mainly in the number of dogs he owns. These animals constitute the currency of the people; they supply the place of coin. Wives are purchased in dogs; the price varying from one to ten, according to the youth and comeliness of the woman. The Guiliaks are of an ugly type; high cheek bones, round head, flat faces, and large ears without lobes. Their color is a yellow brown. They are small—the men with little beard—broad shoulders, short legs, and an immense mouth. They are very dirty, the men never washing themselves except in winter, and then with seal grease. For a woman to wash herself is considered an unpardonable sin.

Each village is usually made up of members of the same family. A Guiliak comes into the world with so many fathers and mothers that it is difficult for a stranger to determine his actual parentage. A child calls "ytk" not only his proper father, but the latter's brothers and first cousins, and "ymk" his mother and her sisters and first cousins. Marriage between blood relations is forbidden. When a child is born it receives a name. If through carelessness it is that of a person still living, both, it is supposed, will die within a year. The names of the male children are significative of strength, courage, or intelligence; those of the females relate to some incident of the moment. M. Labbé tells of one who was named "Incendiary,"

HAIRY AINO OF YESO, JAPAN.

because a fire was raging at the moment she was born. Another was called "Abundance of Fish," because her birth was coincident with a phenomenal run of fish. Brothers and sisters are allowed to play together until they reach a certain age, when they are separated and not permitted even to speak to each other except with averted eyes. The boys are taught to fish and hunt; the girls are instructed in household duties.

The Guiliaks are polygamists, although polyandry prevails among them to a certain extent. M. Labbé tells of one who had two wives. He desired to sell the older of the two, although he acknowledged she was the more useful to him. He had paid three dogs for this lady, with an annual tribute to her father of a single one. He had died. The husband thought that this released him from payment of the yearly tax, but the heirs of the deceased disputed it. He was at the moment negotiating with them, offering to restore the lady to her relatives, on the plea that a dog was of more use to him than a wife.

In marriage the consent of the girl is not required. She is purely an object of barter. A man cannot purchase a second wife without the acquiescence of the first one. Married women are usually well behaved. They perform all the hard labor. When they go to the woods to collect fuel they go in groups under the surveillance of a chaperon, an old man expert in the business. He, however, is sometimes foiled. The author tells of a youth named Drivin, very good looking and a glib talker. He was a roué, the terror of husbands and chaperons. He was asked why he did not marry. "What is the use," he replied, "to pay out dogs when all the women are chasing me?" When an elder brother absents himself from home, if he has a younger one, the latter assumes the other's marital rights during his absence. The elder brother under similar circumstances has no such claim on the wife of his junior. To avoid paying the purchase price of a wife, young men of one village sometimes make a raid on a neighboring one and carry off the marriageable girls. These forays lead to bloody reprisals. Peace is not restored until ample compensation is made in dogs.

The Guiliaks look upon disease as a punishment inflicted by evil spirits for various sins. The more serious are murder, rape, permitting the household fire to be extinguished, spitting in it, curing seal grease otherwise than by the heat of the sun, etc. Curative active methods are very primitive. Fevers and headaches are treated by scarifying the forehead and pinching the skin until the blood flows. Sore eyes are poulticed with the bark of wild cherry. Cataplasms of wet earth are used. The most effective cure is thought to be a talisman of which every family has one or more. They have doctors or sorcerers who indulge in the mummery of their kind. Of late, however, they have come into disrepute on account of a growing scale of charges for medical attendance. When they were content with donations of fish or game they were held in high regard; but now that they are asking for a dog for each professional visit they are not much employed.

The Guiliaks are inveterate story tellers. Suicide of unhappy lovers is their favorite theme. M. Labbé tells of one named Nianquine, a famous *raconteur*. He never finished his stories. At a particular point he always began to weep. When asked the wherefore he said that the remainder of the narrative was so sad he could not sufficiently control his feelings to finish it.

The Aïnos, the second of the aboriginal tribes on the island of Sakhalin, are objects of even greater interest. They occupy the southern end of the island. While they and the Guiliaks have a good deal in common, the Aïnos are more civilized—at least a portion of them—owing to intercourse with the Japanese, who have established fisheries near some of the villages and given them employment. Through this association they have been able to supply themselves with modern tools. Moreover, the Japanese have taught them how to enlarge their physical comfort. The Aïnos are more reserved and less confident of themselves than the Guiliaks. When a stranger enters the hut of the latter he is greeted with laughter and childish antics; when he goes into that of the other he encounters serious, grave reserve. M. Labbé says that the conversation of an Aïno is tinged with melancholy. His stories or legends are full of sadness.

To-day in the Japanese island of Yeso there are flourishing schools attended by Aïnos. Among the most intelligent citizens of Tokio are many who, although they try to conceal it, are of Aïno descent. These aborigines have a legend which tells why the Japanese can read and write and they cannot. "On a certain day a Japanese god came to pay a visit to an Aïno deity. The latter asked his confrère to remain and dine with him. The meal was a copious one. What better could two gods do, when dining together, than get drunk? The Aïno deity fell asleep. The Japanese god took advantage of the opportunity and robbed him of his grammar and written language. That is why the Japanese know how to read and write and the Aïnos do not."

The Russians have attempted proselyting among the Aïnos, but with little success. They cannot be weaned from the idea that a god is other than vindictive and cruel. They devote themselves to the propitiation of malevolent deities. M. Labbé gives an example of this characteristic of the Aïnos. Poutka, one of the companions of the author, was a big Aïno, very jovial and obliging. With his long black beard and ragged clothing he had the air of a brigand, whereas he was the most gentle of men. Always in his company was a certain Otaka, a most intelligent person, who told melancholy stories and recited Aïno legends. He spoke Russian very well and was fond of theological discussion.

"A Russian pope," he said to the author, "tried to convert me to his religion, but he was only the priest of a false god. He depicted his God as beneficent and good, always ready to protect man and pardon him. A God as benevolent as that cannot exist: it is useless to pray to Him because he cannot do us any harm. Gods are wicked and they amuse themselves in seeing us suffer. Often a poor little rat comes out of his hole in our village, the dogs run after him, barking

AINO THATCHED HUTS.

PRAYER STICKS.

THE AINOS, A PRIMITIVE PEOPLE OF JAPAN.

and snapping. They seize and play with him. He suffers for a long time. Now, the evil spirits and gods are like these dogs. This poor little rat is the unhappy Aïno whom they torture for their pleasure."

Labbé asked Otaka if he thought gods and evil spirits could be placated with prayer.

"No, I do not think so," he replied. "When the snow falls and the sea is furious the Aïno lost in the forest or tossed about in his boat by the waves weeps

A COAT MADE OF BARK.

and prays. But the snow continues to fall and the tempest increases in fury. The gods only spare those who give them food and drink. A prayer to them signifies nothing. The Russian pope told me that we had a soul and that that soul when we died would live with God. I do not believe that. If the dead lived in another world they would be concerned about us. I had a son who died young, a father who lived to a great age. If to-day they were with God they would make me feel it, they would let me know it; for they loved me too dearly to leave me inconsolable and weeping for so long a time."

"There is a proverb in my country," said Labbé, "which pretends that when one is dead it is for a long time."

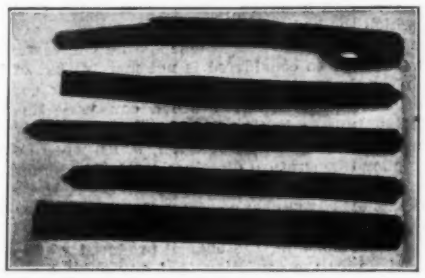
"Your proverb lies," replied Otaka; "when one is dead it is for all time."

Poutka, on the other hand, like most of the Aïnos, believed in metempsychosis; that when a man died, if he had conducted himself properly in this world, he would inhabit the body of a superior animal, like a seal, a dog, or even a bear. This conversation is given to show how the intelligence of aborigines like the Aïnos can be awakened by contact with a race like the Japanese, and how it can be kept dormant, as in the case of the Guiliaks, through exclusive association with Russian convicts.

The Japanese have relations with only a limited number of Aïnos. Those who do not come in touch with them are no further advanced in civilization, so to speak, than the Guiliaks. Their customs and habits are relatively the same, modified by local conditions. One of the distinguishing characteristics of the Aïnos is intense love of children. This refers not only to their own, but to those of relatives and neighbors. They hasten marriage in order that this form of affection can be satisfied at the earliest moment. A boy marries at thirteen and a girl at twelve. Parents affiance their children even when they are in the cradle. When a young Aïno wishes to marry he goes hunting, passing through several villages. If in any one of them he encounters a young girl who pleases him he asks the price at which she is held. If his parents are able to pay it the couple are married forthwith. The tariff varies from four to six dogs or a dozen sable skins, a boat, or a sled. If the girl's father has no son the young couple live with him. In case he has one they go to the husband's father or to live with an elder brother, or to a house specially built for them.

In one case out of six the wife is older than the husband. Sometimes there is a difference of ten or twenty years. This arises from the fact that if an older brother dies leaving a widow and younger brother, the latter marries her. This is from motives of economy; for the widow, being already a member of the family of the young husband, he is not obliged to purchase her. Later on, if he wishes to marry a young woman, he cannot do so without permission of the older wife.

Twice yearly a Russian convict ship sails from Odessa for Sakhalin. The prisoners are confined in the hold in iron cages. Before sailing there is a medical inspection, but it is so careless that convicts ill of serious maladies and in the last stages of tuberculosis are allowed to embark. Many of those affected die during the voyage. The convicts have leg irons until they reach the Red Sea. There the heat becomes so intolerable that it is necessary to remove them. Every day they are brought up between decks, in groups, and the ship's hose is turned on them; otherwise they would not be able to endure the suffocating air of their cages. In the tropics they are allowed to discard clothing. About eighty convicts are confined in each cage. They are so crowded that in sleeping the head of one rests on the body of his neighbor. Punishments administered while on the ship are very severe—the



MUSTACHE LIFTERS.

AINO WOMEN WITH TATTOOED MUSTACHES.

whip, irons, and confinement in a dark cell where the prisoner can barely breathe. In 1901, in midsummer, one of these convict ships was obliged to remain at Saigon for several weeks to make repairs. Eight hundred convicts in the terrible heat and their disgusting promiscuity, suffered indescribable agonies. When the convicts arrive at Sakhalin they are distributed among the six prisons on the island, two on the west coast, three in the interior and one in the southern portion. M. Labbé visited all of them, and underwent temporary confinement in one in order to get "local color." One prison resembles the other; great wooden barracks, with an interior court into which the cells open. Sometimes as many as fifty convicts are crowded into a single cell. Each prison consists of two divisions—one of correction, the other of amelioration.

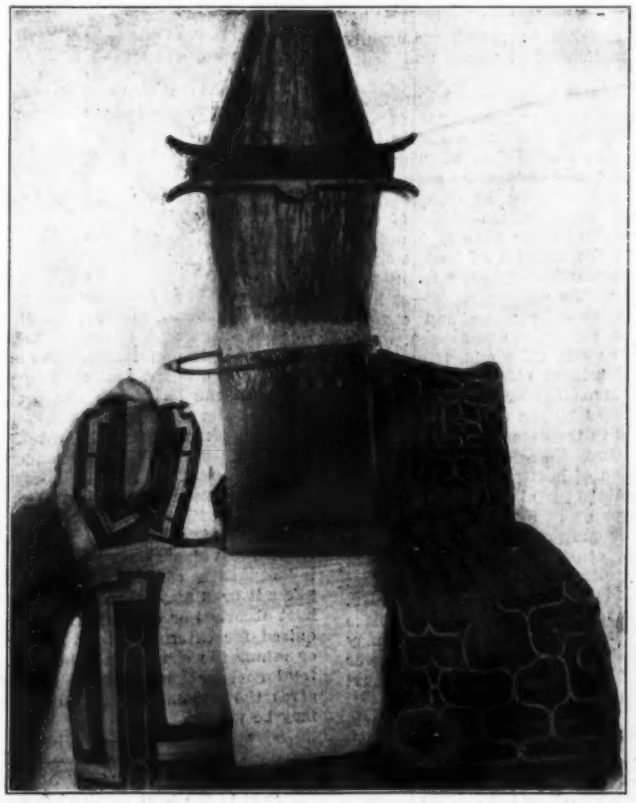
Convicts condemned to life imprisonment remain eight years in the first and two in the second. Those sentenced to more than twenty years at hard labor have the period of confinement gradually reduced until those deported for minor offenses suffer only nominal sequestration. When convicts have completed their term in prison they are supplied with an ax, saw, and ropes, and sent into the interior as colonists. For two years, while they are building a hut and clearing the ground for cultivation, they are supplied with provisions; after that they are obliged to support themselves upon what they can get from the soil. Their condition is so wretched and they are so near starving that many commit crime in order to be returned to prison. After fourteen years of service as convict colonists they are called "peasants." They then have the privilege of living on the mainland or even of returning to European Russia.

A good many convicts succeed in making their escape. In summer they hide in the holds of boats sailing across the narrow strait which separates Sakhalin from the mainland. In the winter they are able to cross on the ice. If they succeed in evading the vigilance of the coast guards they have a long perilous journey on foot across Asiatic Russia before them. One female convict and her three children—shoeless—succeeded in accomplishing it. When she reached her native village in Russia she was recognized, arrested, and returned to Sakhalin.

M. Labbé calls the directors of the prisons "sinister personages." They are the real masters of the island. The other functionaries are mere tools in their hands; spied upon by convicts set to watch them in the hope that they may be detected in some deviation from which the directors may profit. These sell on the sly to merchants on the island goods made in the prisons. In this way they would gain enough to make themselves independently rich, were it not for their passion for gambling, which puts in circulation the money of which they are defrauding the government. Moreover, these directors are mercilessly cruel to the poor creatures over whom they rule. For amusement they will inclose a convict in a barrel and roll him down a hill. The whistle of the lash of the whip is music to them. Yet M. Labbé says there is no instance of a convict attempting the life of a director of prisons. They are so terrorized and cowed that all spirit of resistance or revenge is crushed out of them.

There is great inequality and injustice in the treatment of the convicts. To a good looking woman prisoner life is made very easy and agreeable. It is the same with a man who has money to bribe officials. A young criminal of a family of influence committed for murder has it changed into a political offense and enjoys the privilege granted this class of offenders. A Russian officer of rank was sent to Sakhalin for selling military secrets to a foreign power. He was put in charge of confidential papers relating to the administration of the island. M. Labbé had barely arrived at Sakhalin when this officer came and offered to sell him copies of these documents.

It may be asked why are all these things, these injustices and cruelties, possible? There are supposed to be inspectors sent from St. Petersburg to remedy these evils. They are sent, but no sooner do they arrive than they disappear with mysterious promptness. There is a governor of the island. He is full of good intentions, but his term of office is so brief that he is little better than a visiting stranger. He sees only what he is permitted to see. In fact, he learns less than a visitor. Officials avoid meeting him; everything is hidden that can be concealed. An honest official does not dare speak. One who instituted inquiries in regard to the great sums of money that his subordinates with mod-



NATIVE LOOM, SHOWING ROLL OF BARK CLOTH AND GARMENTS.

THE AINOS, A PRIMITIVE PEOPLE OF JAPAN.

est salaries were wagering at cards was immediately dismissed from office. A convict said to M. Labbé that what he was relating seemed to frighten him. What would be the effect upon his auditor if he told the full truth? Yes, notwithstanding the frightful punishments dealt out to the convicts, the colonist prisoners consider their life so much harder that, to escape it, they would willingly return to prison.—New York Sun.

THE PHYSICAL NOTIONS OF ENTROPY AND FREE ENERGY AND THEIR IMPORTANCE IN GENERAL CHEMISTRY.*

By E. P. SCHOCH, University of Texas, Austin.

THE study of physics which teaches that energy relations determine the course and amount of physical changes naturally inclines the student of chemistry to the belief that energy relations play a similar part in chemical phenomena. The observation that chemical actions are frequently accompanied by evolution of heat naturally suggests that the amount of heat possibly evolved may serve as an indication of the direction of chemical reaction and may serve to measure the amount of change in any case. Facts show that *both* of these notions are wrong. Under certain conditions many reactions proceed in such a sense as to liberate heat, while under other conditions they take place with absorption of heat. Though there are many reactions which proceed in such a sense as to evolve heat, it is due to the fact that the *conditions* which naturally obtain are such as to *produce* this result. On account of the predominance of the number of these cases chemists have accepted this "half truth" as the whole truth, and even now this erroneous notion is *current*.

Not only does the heat change not indicate the direction of chemical change, but it is not *in general* a measure of it. While for any *one* reacting mixture the amount of change is proportional to the amount of heat cooled (or absorbed) and for the reverse change the same proportional amount of heat will be absorbed (or evolved), yet for comparing the amounts of change among different substances the heat change does not serve as a measure except under certain conditions. These conditions frequently naturally obtain, and thus it has come about that this "half truth" also is held by very many chemists as the "whole truth." Especially is this true among technologists, who for economic reasons need a measure of chemical changes in terms of energy. Practical electro-chemists constantly calculate the decomposition tension of electrolytes from the heats of formation, though the two quantities are but rarely the same. The error in this whole idea is shown most strikingly by the following fact: Hydrogen gas changes to hydrogen ions unaccompanied by any heat changes. Here evidently the amount of chemical change is not measured by the amount of heat change.

But our science has not merely succeeded in negativing the early attempts in this direction—it has produced something in place of it. It is the object of this paper to indicate briefly and in as concrete a form as possible some of the most fundamental results which have been definitely established, but which are usually expressed in abstract mathematical terms, and hence are not "current."

Changes in physical bodies which may be produced or accompanied by the addition or abstraction of heat are measured in terms of *entropy*. At a glance it is seen that this includes all chemical changes. The addition or abstraction of heat may change the energy contents of the body, as, for instance, by changing the temperature of the body, or at certain points of temperature, the state of aggregation; thus at 0 deg. C. ice changes to water on the addition of heat, etc.; or again, the addition or abstraction of heat may produce chemical changes, such as the decomposition—at high temperatures—of steam into hydrogen and oxygen. Thus a mixture of steam, hydrogen, and oxygen, which is in equilibrium at 1,500 deg. C., would, if cooled or heated, change to a mixture of different proportions, and *some* of the heat given out or taken up by the mixture would be produced by the union of hydrogen and oxygen or consumed in the decomposition of steam through which the mixture changed its composition. Furthermore, the addition of heat may cause the body to expand if the surroundings permit it. Thus the addition of heat to a gas confined in a cylinder closed at one end and at the other end provided with a movable piston against which a constant pressure is exerted will cause the gas to expand against the pressure on the piston. Thus work is done and energy expended.

Under what conditions must the change take place in order that a heat change externally observed may alone be effective in producing the change? To answer this question the effect of heat on a physical body must be considered in detail.

The heat received by a body may be retained as such, or it may be partly or wholly expanded while the volume energy increases. By this latter term is meant the product of the internal pressure with which the body tends to expand, multiplied by the volume through which it expands.

The volume energy of a body would evidently change without expending any internal energy; thus a gas may expand into a vacuum; a salt may dissolve in a solvent where the expanding substance does not have to overcome any opposing pressure and hence no energy is used to do external work. But if the external pressure is just equal (in reality it must be slightly less) to the internal pressure then the external work done is equal to the volume energy change, and hence the volume energy change equal to the internal energy consumed. Under these conditions the heat obtained from without is equal to the increase of internal energy plus the change in volume energy. Hence, if a body is to undergo no change except that due to the addition of heat, then any volume change which it experiences must be under such conditions that the change in volume energy shall have consumed an equal amount of internal energy and that is the case only when the external confining pressure is just equal to the pressure with which the body tends to expand.

The volume change needs some special consideration. The volume to be considered is not merely that of the total mass, but rather the specific volume or concentration of each constituent which can vary its concentration independently of others. Thus, a mixture of a salt and its saturated solution, which when heated to a higher temperature dissolves more salt, undergoes not only a change in external volume, but the additional salt dissolved changes from the volume occupied in the solid state to a much larger volume in the solution. Let us consider the change produced when heat is added under the condition that any volume change shall consume an equal amount of heat. First of all, we find that only heat which is at the temperature of the body can be considered in calculating the "amount of effect," because heat in surroundings which are at a lower temperature than the body does not flow into the body, and heat coming from surroundings which are at a higher temperature could do more than merely enter the body and its addition transform it: while falling in temperature the heat could produce work through the agency of a proper heat engine, and yet when delivered from the engine at the temperature of the body it can enter it and change it thereby. Thus, it is seen that only heat at the particular temperature of the body is able to enter the body and *do nothing else*. The question arises: When a body has been changed by adding to it a quantity of heat, Q_1, at the temperature, T_1, how much heat must be taken away at any other temperature T_2 so that the body is changed back to its original state? To solve this, the considerations and results involved in Carnot's Cycle will be employed. These considerations may be found in any large text on physics. The result usually appears thus:

$$Q_1 - Q_2 = \frac{(T_1 - T_2)\, Q_1}{T_1}$$

The body operated upon in this case is a gas. During the changes the external pressure is constantly equal to the internal pressure—hence from the foregoing it is seen that the gas which receives Q_1 units of heat at T_1 constantly retains this energy either in the form of internal or volume energy until it gives up Q_2 at T_2. From this point on all remaining energy is retained, although it is changed partly from volume energy to internal energy or *vice versa* in equivalent amounts. At the end the gas is in its original state. The above formula readily simplifies to

$$\frac{Q_1}{T_1} = \frac{Q_2}{T_2}$$

Thus a gas that cannot change except through the heat added or abstracted experiences an amount of change expressed by $\frac{Q}{T}$; a change produced by one $\frac{Q_1}{T_1}$ may be reversed by taking away any other quantity Q_2 at T_2 so related that

$$\frac{Q_2}{T_2} = \frac{Q_1}{T_1}$$

When the body is under such conditions Q is said to be its change in entropy. It may readily be shown what is thus true of a gaseous body is true of any solid or liquid body or mixture. The apparently queer part in the above is the fact that any external work done by or on the body does not produce a change in it and affect its entropy.

To consider the measurement of entropy on the body itself, let us take a mixture under such circumstances that outside of volume changes it does not give up energy in any form except heat, but, contrary to the foregoing, with *no restriction upon the external pressure*. This is the case in most chemical reactions, because the volume energy change takes place entirely independently of the heat change, and may not even affect it or it may increase it or decrease it. Then the heat absorbed or evolved *minus* or *plus* the amount required for external work to change the volume, *plus* or *minus* the change in volume energy represents the total energy change, which as before, divided by T, gives the amount of change in entropy units. This may be written

$$\frac{Q - W + pdv}{T}$$

where Q is the heat received from the outside, W the external work done, and pdv the change in volume energy. When the change extends through different temperatures the sum of all changes taking place at the different points of temperature must be considered.

Here $(Q - W)$ is the change in internal energy. When the change takes place under such conditions that $W = pdv$ (i. e., when the external pressure is equal to the internal pressure which is exerted to produce change of volume), then the expression correctly shows what was seen before—that the entropy change is due to Q only. But in general this condition does not obtain, and the entropy depends on both the total change of internal energy $(Q - W)$ plus the volume energy change, which latter, as shown above, may take place entirely or partly independently of the internal energy change. That this independent change in measure and effect is equal to a heat change, and hence the two added together determine the change in entropy, may be understood from the following examples: When a gas expands into a vacuum its temperature does not change, and hence its internal energy is unchanged. We say its volume energy has increased by pdv. But to bring the gas back to its former volume work in amount equal to pdv will have to be done to compress it. As a result of this work, the temperature of the gas rises corresponding to an increase of heat equal to pdv. Now, this compression is under such conditions (see above internal and external pressures practically equal) that the entropy can change only by the body's receiving or giving up heat as such to the surroundings. Hence the gas had the same entropy at the end that it had just after expanding into vacuum, and this value is plainly greater than its entropy value at the very beginning by the amount of volume energy change, pdv.

In many cases W and pdv are zero. Thus at 0 deg. the change of ice to water is measured by the heat rendered latent. Again, when a gas expands into a vacuum, Q and W are zero and the change is measured by the increase in volume energy.

This means of measuring changes also takes care of such peculiar cases as the change of hydrogen to hydrogen ions. Here again Q and W are zero, but pdv measures the change.

The immense importance of the idea of entropy to the chemist probably justifies the length of the preceding statement, though it is not claimed that the presentation is more than a mere indication intended to help remove the notion that entropy is a mathematical quantity without physical meaning.

Side by side with this result that thermo-dynamics has produced for chemistry and which gives the *correct* notion in place of one of the two "errors" set forth in the introduction we shall present the corresponding result obtained in place of the other error—namely, an expression involving energy measurements which indicates the *direction* of possible change of a mixture. By far the greater number of chemical reactions take place practically at one particular temperature—isothermically and without the performance of external work. Under these conditions the heat evolved or absorbed practically represents the change in internal or total energy. The change in entropy involves in this case only one temperature, and multiplying the entropy by this T gives the latent energy which is absorbed or evolved during the change which added to or subtracted from the latent energy in the mixture before change gives the amount of latent energy necessary for the body to remain in the resulting state.

It has been found that the expression

$$(U_1 - U_2) - T(\Phi_1 - \Phi_2)$$

always gives a positive quantity whenever a mixture with the internal energy U_1 and entropy Φ_1 undergoes reaction, producing a mixture with the internal energy U_2 and entropy Φ_2. Hence any mixture which by reaction can produce a mixture of which the relation of the internal energies and entropies as per above expression gives a positive quantity is certain to react. This difference between changes in *total* and *latent* energies is called *free energy*. At any one constant temperature reaction takes place only with the expenditure of free energy. Here, then, is a quantity derived from energy relations which indicates whether or not reactions may take place in a particular mixture.

With this expression it may be understood why reactions may take place with *absorption* of heat even. Such absorption of heat would make U_2 larger than U_1. Yet if Φ_2 is sufficiently larger than Φ_1 this negative quantity $(\Phi_1 - \Phi_2)$ subtracted from the negative quantity $(U_1 - U_2)$ will still produce a positive difference.

The amount of free energy may be measured when the mixture reacts under certain conditions, and these measurements represent to a certain extent differences of chemical *potential*. These determinations have done service particularly in calculating the electromotive force of battery cells. It is ordinarily assumed that the electrical energy obtainable from a certain battery cell may be calculated from the heat of reaction of the compounds of the cell. This is an error. In some cases more electrical energy is obtainable, in others less, than corresponds to the heat evolved. However, the electrical energy is equal to the *free* energy. In all cases the free energy is a measure of the maximum work obtainable from a chemical reaction. Hence its value. The importance of the conception of *free* energy in general chemistry has been acknowledged by as great an authority as Ostwald, who sets it forth in his "Principles of Inorganic Chemistry."

* Read before the Texas Academy of Science at Austin, Texas, January 20, 1905.

COLOR IN PLANTS.

NEITHER the elements of leaf-green nor how this substance performs its work is yet known. You have noticed, doubtless, that most leaves in the bud are pale in color. Plants grown in darkness are of a sickly yellow. The pulp which is contained in the plant cells and which gives this tint is called etiolin. It is supposed to be the antecedent condition of the formation of chlorophyl, as leaf-green is called. The term "etiolin" is derived from the French word, meaning "to blanch." An "etiolated" plant is a blanched plant. The term is also applied to pallor in persons.

Exposed to light and warmth, however, an etiolated plant rapidly changes to vivid green. A very few hours' exposure to sunlight turns etiolin to chlorophyl. It is true that some ferns have been known to form leaf-green in darkness, but only under a high temperature, a fact that suggests a "cooking process" in the act.

It is curious that chlorophyl extracted from plants and made into a thick layer appears of a deep lake red on the surface. Held between the eye and the light, however, it is of a rich green.

Along with leaf-green other colors are associated in plants. The term "chromule" is applied to these in general. They are always present in a lesser or greater degree. A few weeks ago the young leaves availed themselves of chromule. Those of the birch were purple, those of the oak pink and bronze, and the tips of the maples were all scarlet. Then the blossoms claimed it. Here the student of Nature stands before the closed door of one of her greatest mysteries. By what marvelous chemistry does she paint, out of the same soil and light and air and heat and rainfall, the lily, with its cup of pearl, the violet, darkly blue, the cardinal flower, the golden rod, and the marvelous painted cup of the morning glory?—English Mechanic.

CONTEMPORARY ELECTRICAL SCIENCE.*

RADIO-ACTIVE MATTER IN THE ATMOSPHERE.—A. S. Eve has estimated the amount of radium required to maintain a steady supply of the emanation in 1 cubic kilometer of air near the earth's surface, and finds it to lie between 0.14 and 0.49 gramme. This amount and its successive products cause a production of ions at the rate of about 9.6 per cubic centimeter per second. The radium emanation in the air is probably sufficient to account wholly for the natural ionization observed in large closed vessels consisting of non-radio-active materials, and for the rate of production of the ions in the atmosphere near the earth. The collecting distance of a wire charged to a negative potential of 10,000 volts is about 40 to 80 centimeters. The active matter derived from the carriers is not drawn in appreciable quantities from still air at a greater distance. Assuming that the radium in the earth is equally distributed in amounts sufficient to maintain the temperature gradients actually observed in the earth, then the radium emanation in the air is derived from an average depth estimated to be between 5 and 17 meters. All these estimates are based upon Montreal conditions. Similar estimates should be made elsewhere. Experiments with airtight tanks are specially useful.—A. S. Eve, Philosophical Magazine, July, 1905.

A NEW RADIATION.—B. Walter has found that the α-rays emitted by polonium have the property of imparting an ultra-violet radiation to nitrogen. This may be shown by covering a photographic plate with a sheet of lead having several perforations closed by various substances such as aluminium or platinum foil and glass. Under the latter a strong impression is found after exposure to polonium rays, while the aluminium transmits nothing and the platinum very little. When a thin wire is laid across the holes as well the platinum transmits a sharp but faint shadow, attributable to the original α-rays. The glass transmits a fuzzy shadow of the wire, showing that the transmitted radiation does not arise from the polonium. By interposing various screens the author succeeded in showing that the new radiation consists entirely of ultra-violet light, and has a maximum at a wave-length of about 300 $\mu\mu$. In a vacuum the effect disappears, and also on substituting water or hydrogen for the air. Nitrogen shows it very strongly. The radiation may be completely intercepted by an ammoniacal solution of umbelliferon, which is known to intercept all the ultra-violet rays near the visible spectrum. It makes no difference if the air or nitrogen is dried, or whether it is passed through in a quick or slow current.—B. Walter, Annalen der Physik, No. 7, 1905.

EMISSION SPECTRA OF VACUUM TUBES.—By means of a radiometer fifty-two times as sensitive as Boys' radiomicrometer, W. W. Coblentz has studied the infra-red emission spectrum of vacuum tubes filled with different gases. The author finds that only hydrogen and nitrogen have an appreciable radiation near the visible spectrum. All gases examined, except water vapor and hydrogen, have an emission band at 4.75μ, but this is probably due to carbonic oxide. This band exhibits a remarkable behavior. Its intensity increases with increasing pressure, but never reaches a maximum, becoming quite asymptotic at 5 millimeters to 6 millimeters pressure. The other bands have a maximum at 2 millimeters pressure. Everything goes to show that the bands near the visible spectrum are related to the visible bands of nitrogen and hydrogen, but the 4.75μ band is of an entirely different type. The author offers the following tentative explanation for these two very different kinds of radiation. It seems the most plausible one of a number that present themselves. Consider the lines near, and in, the visible spectrum. At higher pressures the electrons will not attain a high speed and their freedom of motion will be limited; at a lower pressure their freedom of motion will be greater, the number of impacts will be more frequent, and the "electrical temperature," which is proportional to the mean square of the ionic speeds, will attain a maximum. At a still lower pressure, due to the scarcity of ions, the impacts decrease in number in a given time, and the electrical temperature decreases. On the other hand, the band at 4.75 μ appears to be due to a thermal radiation, excited by the impact of electrons with the gas molecules which will grow warmer and in colliding with other molecules, on account of their temperature, will emit heat waves. With increase in pressure (i. e., number of gas molecules) the number of collisions will increase, the intensity of radiation will increase, but will not pass through a maximum, as is true of the other bands.—W. W. Coblentz, Physical Review, June, 1905.

*Compiled by E. E. Fournier d'Albe in the Electrician.

SCIENCE NOTES.

Empiricism is one of the legitimate aids to science. A great inventor like Edison who wishes to find a certain property tries in logical sequence everything that is practicable, and often it is only after thousands of trials that the substance having the requisite quality is found.

Photosynthesis is a topic which has received a full share of physiological investigation throughout the past century; yet the problems demanding attention are too numerous for complete enumeration. The mechanism of gaseous exchange in leaves has repeatedly been experimentally proved to be the function of the stomates. After critical physical experimentation, Brown and Escombe have recently reported that the results of their studies of diffusivity through multiperforate septa are closely applicable to the herbaceous leaf with its stomates and substomatic chambers. Assuming their calculations to be correct, and granting that all of the incoming carbon dioxide is removed, it is estimated that with the stomates open the maximum observed rate of fixation of CO_2 in *Helianthus* (which is 0.134 cubic centimeter per square centimeter per hour) would be only 5.2 to 6.3 per cent of the theoretical capacity of the diffusion apparatus of the plant. In other words, with a gradient between the outer and inner air of only 5 to 6.5 per cent pressure, the maximum observed fixation is well accounted for.

Of the production of castor beans in the United States historic records are meager. The plant is not indigenous to the Western Hemisphere; but philological research has led to the belief that it was introduced into the West Indies soon after their discovery. It is known to have been extensively cultivated in Jamaica in the eighteenth century, and to that fact can probably be credited the curious application of the word "castor" to this plant and oil. Resident Spaniards and Portuguese, having confused it with a totally different plant, the *Vitex agnus castus*, called it "agno casto." From this designation the English who traded in this oil coined the word castor, and thus gave rise to the name since applied to it throughout the English-speaking world. This certainly seems a more reasonable origin of the word than that attributed to its fancied resemblance to castoreum, a product obtained from the beaver. The man who first brought castor beans into the United States has left no record of his achievement, and succeeding generations who fostered his enterprise have been scarcely less mute. A small crop, limited, at even the highest stage of its development, to groups of counties rather than to States, its early history is naturally lost in oblivion. The salient fact is that the crop has always been largely localized in parts of the States of Illinois, Missouri, and Kansas, and the Territory of Oklahoma. Incidental mention is found of its cultivation in Illinois before that State was admitted into the Union in 1818. Within the next quarter century there are occasional references to experimental culture in Georgia and other Southern States. But not until 1850 were there comprehensive data indicating the geographical distribution and extent of the crop.

The effect of surface and brush fires in large timber is more serious than is generally supposed. The prevailing opinion is that mature timber is not injured by such fires, and this has created among lumbermen a feeling of indifference to their occurrence. Few fires in a forest are so slight as to produce no ill effects. Though most of the trees may escape with only a slight blackening or charring of the bark, there are invariably others which are killed or injured at the base by the burning of brush and débris accumulated about the trunk, or by the fire catching in a break in the bark. Each successive fire adds its percentage of injury, while all damaged trees are rendered less wind-firm. Even in the southern pines, where the fire injury is near the minimum, the cumulative damage is surprisingly great. The Bureau of Forestry has obtained figures which show that in a turpentine orchard of Florida long-leaf pine, abandoned for five years, 33 per cent of the trees above a diameter of 1 inch were found dead or down, mainly as a result of fire, while only one-half of 1 per cent of the remaining boxed trees were unburned. The damage in unboxed long-leaf pine of the same region was much less serious, 82 per cent of the stand being sound. Throughout California the opinion so largely prevails that fires in virgin timber are comparatively harmless that lumbermen allow them to run unless they threaten their mills or are likely to spread to "slashings" in dangerous proximity to valuable timber. This, too, is in the face of the fact that nothing is more noticeable in the Sierra forests than the burned-out bases of many of the finest sugar and yellow pines. Figures obtained in the logging camps of a lumber company in Tehama County show that the "long butting" necessitated by the burns in the base logs amounts to about 4½ per cent of the total cut, which is a direct loss of this amount. This does not include the loss in high stumps, where the cut is made above the burn, nor allow for the deduction from the actual scale reading in partially burned-out logs, nor for the inferior lumber near the burns, where the heat has hardened the pitch. In addition to this, many trees have burned down or have been thrown by wind as a consequence of the fire.

ENGINEERING NOTES.

Almost every engineer and electrician is familiar with the fact that the majority of steam-power plants are not operating under the most economical conditions. In some cases this is due to the plant having been built up piecemeal as the requirements developed and in other cases it has been found difficult to determine the amount of power that would actually be required until after the plant was completed. If the consulting engineer could be informed, or could determine in advance the exact requirements for the present and future, it would be comparatively a simple matter to design the plant with fair accuracy as to the size and number of units, types of engines, boilers, and other details.

The best solution of the smoke problem, so far, has come from the introduction of mechanical means of handling the coal, which give a uniform feed to the fuel and a corresponding delivery of air for combustion. The use of mechanical stokers has been brought about by the natural demand for machine handling in large power plants as more economical than human labor, rather than by a philanthropic desire to benefit the community. It has been estimated that one able-bodied man with a shovel and slice-bar can take care of 200 horse-power of boilers. With good mechanical stokers he can handle double, and with complete coal and ash-dumping equipment three times this amount.

The steady increase in the weights of locomotives and rolling stock has been the cause of constant replacements of iron and steel railroad bridges by heavier structures. As the extreme limit of loads may not yet have been reached, the probable future increase should be anticipated in designing new bridges which have to carry any kind of railroad traffic. While it is impracticable to provide for all possible emergencies, railroad bridges should be designed to withstand the ordinary contingencies of traffic, such as derailment, a broken axle, or a collision on the bridge. Structures designed in accordance with good practice may be damaged by such accidents, but should be able to stand up without collapsing. As steel is practically an indestructible material, if kept from corrosion, there is no good reason why properly designed steel bridges, properly protected, should not last at least as long as stone bridges in this climate.

The first engineer who seems to have discovered the value of compounding centrifugal pumps—that is, by causing the discharge of one centrifugal pump (either integrally formed or simply in close juxtaposition) to be led into the suction of another similar pump—was the celebrated Swiss engineer, Sulzer, of Winterthur, Switzerland. Sulzer was pretty closely followed by A. C. E. Rateau, of Paris, France, and John Richards, and Byron Jackson, of San Francisco, Cal. The pumps of all these inventors were constructed originally with the impellers facing in one direction, and the consequent thrust upon the impellers was partially taken up by balancing chambers upon the rear of each impeller. This form of balancing was further improved in Rateau's pump by a balancing cylinder at the extreme discharge end of the pump shaft, into which water was admitted from the discharge orifice of the pump. Rateau further attempted to improve the balancing of his pump by constructing inclosed impellers, having one of the side plates of the impellers of smaller diameter than the other, so that the area of the two impeller side plates subjected to the discharge pressure from that impeller was equal. John Richards also used a balancing piston at the discharge end of the pump, directly connected with the discharge pressure, and also attempted further to balance a pump of this type by exhausting the air from one side of the impeller and forcing air in upon the other side.

A criticism frequently made in regard to mechanical stokers is that they will not respond quickly to sudden changes in the load, that it is difficult to keep a uniform steam pressure under such circumstances, and that for this reason they are not economical. There is some truth in this. It is easy to conceive of circumstances, especially in electric plants, under which it would be difficult to maintain a uniform steam pressure with either the oscillating or the traveling grate. For regular fluctuation of load, as in electric lighting or railway power houses, the obvious remedy is the introduction of storage batteries and the provision for ample boiler reserve. Minor fluctuations can be taken care of by the fireman unless they become too numerous or too violent. In the latter case the underfeed stoker with the plunger feed comes the nearest to satisfying the demand. With the power of instantly regulating the motion of the plunger and the pressure of the blast, it is thus possible to meet emergencies of this kind more promptly than by hand firing. The economy resulting from the abatement of smoke is naturally a potent argument in its favor. This phase of the subject has, however, but little to do with the ethics of the question. Once prove that it is practicable to abate smoke and the community has a right to insist on its abatement regardless of economical considerations. It may cost me more to haul away my garbage than to throw it into my neighbor's yard, but that is no argument for imposing upon my neighbor. Fortunately, this difficulty does not exist in most cases, for it may be stated as a general proposition that smoke abatement means economy in fuel consumption. The proof of this statement is extremely simple: fuel economy results from good combustion, good combustion is accompanied by little visible smoke.

TRADE NOTES AND RECIPES.

Artificial Emery.—For making a ton of artificial emery, 1,634 kilogrammes of the following substances may be employed: 759 kilogrammes of bauxite, 700 kilogrammes of coke, and 96 kilogrammes of a flux, which may be a carbonate of lime, of potash, or of soda, preferably carbonate of lime on account of its low price. These materials are arranged in alternate layers and fused in an oven having a good draft. They are said to yield an artificial emery similar to the natural emery of Smyrna and Naxos at low cost, as the electric furnace is not necessary for its production.—Berichte.

Smelting and Casting of Refractory Metals.—Smelting and casting metals with a high fusing point is a difficult operation, for the reason that the metal has to be taken from the furnace with the crucible to the mold and poured into the latter; in this way the metal is brought into contact with the air, and cools quickly. The mold has also to be heated to a high temperature in a special contrivance to prevent failure. In a process recently patented the metal is placed over the mold which it is to fill when melted, and the mold with the contents placed in a fireproof crucible or box, and there tightly inclosed in a fireproof mass. The whole is then put into a reverberatory or close furnace and heated to the fusing-point of the metal, the latter then flowing into the mold.—Technische Berichte.

Artificial Phosphate.—An artificial phosphate has been introduced in Germany by Herr Walters, whose factory is at Magdeburg. It is thus prepared: Melt in an oven a mixture of 100 parts of phosphorite ground coarsely, 70 parts of acid sulphate of soda, 20 parts of carbonate of lime, 22 parts of sand, and 607 parts of charcoal. Run the molten matter into a receiver filled with water; on cooling it will become granular. Rake out the granular mass from the water, and after drying, grind to a fine powder similar to that of the Thomas slag. The phosphate can be kept for a long time in store without losing its quality, for it is neither caustic nor hygrometric. Herr Wagner has, in collaboration with Herr Dorsch, conducted fertilizing experiments for determining its value, as compared with superphosphate or with the Thomas slag. The phosphate decomposes more rapidly in the soil than the Thomas slag, and so far as the experiments have gone, it appears that the phosphoric acid of the new phosphate exercises almost as rapid an action as the phosphoric acid of the superphosphate soluble in water.

Process for Utilizing the Tin and Iron in Tinned-plate Clippings.—The process of utilizing tinned-plate scrap consists essentially in the removal of the tin. This must be very completely carried out if the remaining iron is to be available for casting. The removal of the outer layer of pure tin from the tinned plate is an easy matter. Beneath this, however, is another crystalline layer consisting of an alloy of tin and iron, which is more difficult of treatment. It renders the iron unavailable for casting, as even 0.2 per cent of tin causes brittleness. Its removal is best accomplished by electrolysis. If dilute sulphuric acid is used as an electrolyte, the deposit is spongy at first, and afterward, when the acid has been partly neutralized, crystalline. After six hours the clippings are taken out, and the iron completely dissolved in dilute sulphuric acid; the residue of tin is then combined with the tin obtained by the electrolysis. Green vitriol is therefore a by-product in this process. A. Gutensohn's process, recently patented in Germany, according to the Metallarbeiter has two objects: to obtain tin and to render the iron fit for use. The tin is obtained by treating the tinned plate repeatedly with hydrochloric acid. The tin is then removed from the solution by means of the electric current. The tinned plate as the positive pole is placed in a tank made of some insulating material impervious to the action of acids, such as slate. A copper plate forms the cathode. The dichloride of tin solution, freed from acid, is put round the carbon cylinder in the Bunsen element. Another innovation in this process is that the tank with the tinned-plate clippings is itself turned into an electric battery with the aid of the tin. A still better source of electricity is, however, obtained during the treatment of the untinned iron which will be described presently. The final elimination of the tin takes place in the clay cell of the Bunsen elements. Besides the chloride of tin solution (free from acid), another tin solution, preferably chromate of tin, nitrate of tin, or sulphate of tin, according to the strength of the current desired, may be used. To render the iron of the tinned plate serviceable the acid is drawn off as long as the iron is covered with a thin layer of an alloy of iron and tin. The latter makes the iron unfit for use in rolling or hammer mills or for the precipitation of copper. Fresh hydrochloric acid or sulphuric acid is therefore poured over the plate to remove the alloy, after the treatment with the dichloride of tin solution. This acid is also systematically used in different vats to the point of approximate saturation. This solution forms the most suitable source of electricity, a zinc-iron element being formed by means of a clay cell and a zinc cylinder. The electrical force developed serves to accelerate the solution in the next tank, which contains tinned plate, either fresh or treated with hydrochloric acid. Ferrous oxide, or spongy metallic iron if the current is very strong, is liberated in the iron battery. Both substances are easily oxidized, and form red oxide of iron when heated. The remaining solution can be crystallized by evaporation, so that ferrous sulphate (green vitriol) or ferric chloride can be obtained, or it can be treated to form red oxide of iron.

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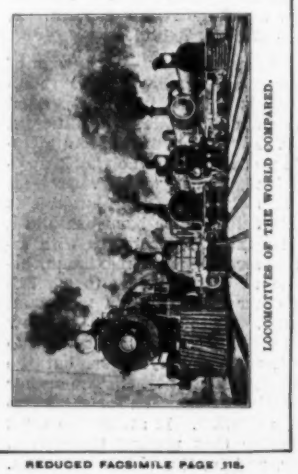

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